SOIL SURVEY

Guthrie County, Iowa

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
THE IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION

Issued April 1974

Major fieldwork for this soil survey was done in the period 1963-66. Soil names and descriptions were approved in 1968. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1967. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agriculture and Home Economics Experiment Station. It is part of the technical assistance furnished to the Guthrie County Soil Conservation District. Funds appropriated by Guthrie County were used to defray part of the cost of this survey.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Guthrie County are shown on the detailed map at the back of this survey. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by mapping units and gives the capability classification of each. It also shows the page where each soil is described and the page for the capability unit and the woodland suitability group in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of use of the soils for crops and pasture.

Foresters and others can refer to the section "Use of the Soils for Woodland," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of the Soils for Wildlife."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Guthrie County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County."

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This CD contains a historical replica of the soil survey of Guthrie County, Iowa. This soil survey was first issued in 1974. Since that time, many of the tables have been updated. To access the official tables for this survey, please access Section II of the electronic Field Office Technical Guide at: http://www.ia.nrcs.usda.gov/.

SOIL SURVEY OF GUTHRIE COUNTY, IOWA

BY ROBERT C. RUSSELL, RAYMOND I. DIDERIKSEN, AND CHARLES S. FISHER, SOIL CONSERVATION SERVICE[1]

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION

GUTHRIE COUNTY is in the west-central part of Iowa (fig. 1). It has a total area of 596 square miles, or 381,440 acres. Guthrie Center, the county seat, is about 54 miles west of Des Moines.

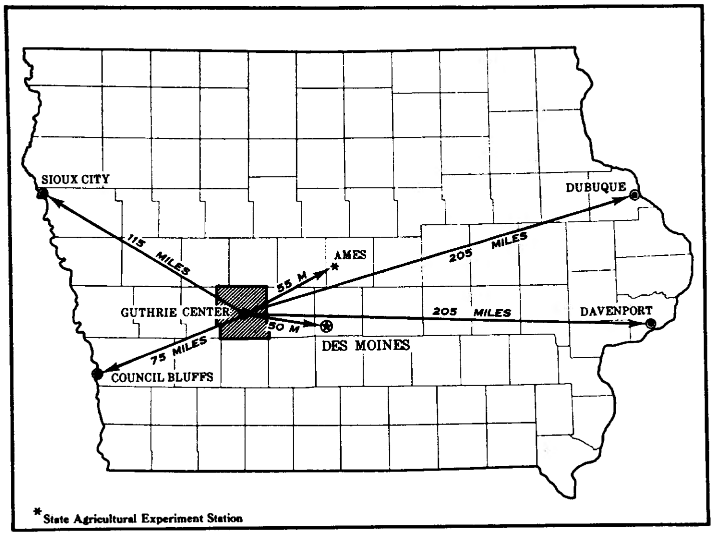

Figure 1.—Location of Guthrie County in Iowa.

The county is primarily rural. The principal crops grown are corn, oats, soybeans, and hay. Soybeans are the most important crop sold, but corn is also important. Much of the corn is fed to livestock. Beef cattle and hogs are the principal sources of income in the county.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Guthrie County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures (*34*).[2] The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Sharpsburg and Shelby, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Hesch loam, 9 to 14 percent slopes, is one of several phases within the Hesch series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

[1] The soils were surveyed and the survey manuscript prepared under the general direction of LACY I. HARMON, Soil Conservation Service, and FRANK F. RIECKEN, Iowa Agriculture and Home Economics Experiment Station. Those participating in the field survey were ROBERT C. RUSSELL, party leader, RALPH L. MENDENHALL, LYLE F. JACKSON, and JEROME KOSTER of the Soil Conservation Service and J. HERBERT HUDDLESTON and J. A. KOVAR, Iowa Agriculture and Home Economics Experiment Station.

[2] Italic numbers in parentheses refer to Literature Cited, p. 115.

Some mapping units are made up of soils of different series, or of different phases within one series. One such mapping unit, the soil complex, is shown on the soil map of Guthrie County.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Colo-Judson complex, 2 to 5 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Alluvial land and Marsh are land types in Guthrie County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Guthrie County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management. The relationship of some of the most extensive soils in Guthrie County to topography and underlying materials is shown in block diagrams in the section "Formation and Classification of the Soils."

The soil associations in Guthrie County are discussed in the following pages. Seven of these associations are on uplands and one, the Zook-Colo-Vesser association, is on bottom lands.

1. Webster-Nicollet association

Nearly level, loamy, poorly drained and somewhat poorly drained soils on uplands

This association is on uplands in the northeastern part of the county. It is drained by three streams that have narrow and, in many places, indistinct flood plains. Tributaries to these three streams are few and short. Most parts of the association lack a natural drainage pattern, and the numerous, extensive, nearly level soils and shallow depressions are tile drained.

This association makes up about 10 percent of the county. Webster soils occupy about 28 percent of the association; Nicollet soils, about 28 percent; and minor soils, the remaining 44 percent.

Webster soils formed in glacial till and glacial till sediments. They are poorly drained. The surface layer is black to very dark gray silty clay loam to clay loam about 18 to 24 inches thick. The subsoil is grayish clay loam or silty clay loam. Webster soils are on broad flats and swales.

Nicollet soils formed in glacial till. They are somewhat poorly drained. Slopes range from 1 to 3 percent. They have a surface layer of black or very dark brown loam. The subsoil is dark grayish-brown light clay loam. Nicollet soils are on slight rises.

The minor soils of this association consist of the poorly drained Canisteo soils in swales and low areas; well-drained Clarion soils; Colo soils on stream bottoms; Cylinder and Wadena soils on narrow stream benches; and Okoboji, Harps, and Storden soils on uplands.

Canisteo soils are the most extensive of the minor soils. They are calcareous throughout. The surface layer is black to very dark gray, and the subsoil is grayish clay loam, sandy clay loam, or loam. Clarion soils are gently sloping to moderately sloping soils that formed in glacial till. The surface layer is very dark brown loam, and the subsoil is brown to yellowish-brown loam. Colo soils are dark-colored silty clay loam. Cylinder and Wadena soils are underlain by sand and gravel. Storden soils are loamy, and they are calcareous at or near the surface. They are steeper than other soils in the association. Harps soils are highly calcareous and occupy rims around depressions. Okoboji soils are very poorly drained soils in depressions.

Most of the soils in this association are used for crops. Corn and soybeans are the main crops. Some oats and crops for rotation hay and pasture, including alfalfa and alfalfa-grass mixtures, are also grown.

The maintenance of tile lines and surface drainage is the main management need. Most areas are tiled, and few additional acres of cropland could be obtained by the installation of additional tile. Maintenance of soil tilth and fertility is also important, because most soils are row cropped intensively. Clarion soils are subject to erosion.

About two-thirds of the farm income in this association is from the sale of grain. Hog raising and cattle feeding are important. Dairying and the raising of cow-calf herds, poultry, and sheep are minor enterprises.

Roads generally are along section or half-section lines, and they are almost entirely hard surfaced or gravelled. Farm fields generally are larger in size than those in other parts of the county and are almost always rectangular in shape.

2. *Clarion association*

Gently sloping to strongly sloping, loamy, well-drained soils on uplands

This association is oriented in a northwest-southeast direction across the northeastern part of the county. It is between the Webster-Nicollet association to the northeast and the valley slopes of the Middle Raccoon River and its tributaries to the south.

This association makes up about 15 percent of the county. Clarion soils occupy 60 percent of the association, and minor soils, the remaining 40 percent.

Clarion soils formed in glacial till. These soils are well drained. They have a surface layer of very dark brown loam and a subsoil of brown to yellowish-brown loam. The soils east of Willow Creek are mainly gently sloping to moderately sloping, and the soils west of the creek tend to be steeper and are generally moderately sloping or strongly sloping.

The minor soils of the association are mainly Webster and Nicollet soils. Webster soils formed in glacial till and glacial till sediments. They have a surface layer of black silty clay loam or clay loam about 18 to 24 inches thick over a subsoil of grayish silty clay loam or clay loam. They are in concave swales and draws on uplands. Nicollet soils formed in glacial till. They have a surface layer of black to very dark brown loam and a subsoil of dark grayish-brown light clay loam. They are generally at the bases of long, gentle slopes but also are on gentle, convex rises in places. At the bases of slopes they are often slightly concave.

Other minor soils are the poorly drained, calcareous Canisteo soils; the well-drained, calcareous Storden soils; the highly calcareous Harps soils on rims around depressions; and the very poorly drained Okoboji soils in depressions. In a continuous area along Willow Creek, Colo soils occupy much of the bottom land and Wadena and Cylinder soils are the main soils on benches. Wadena and Cylinder soils are underlain by sand and gravel. Hesch and Montieth soils are sandy or loamy soils formed in material weathered from sandstone. They are in small areas along Willow Creek south of Bayard. Shelby soils are in the lower tier of sections in Cass Township and in sections 19 and 21 of Dodge Township, where an older, firmer glacial till crops out. Gravelly Salida soils and loamy Wadena soils that are underlain by gravel are on valley slopes of Bay Branch.

The soils of this association are mostly used for crops. Corn and soybeans are the main crops. Some oats and hay and pasture, including alfalfa and alfalfa-grass mixtures, are also grown. There are only a few irregular and small areas in permanent pasture, except in the more sloping soils in the northwestern part of the association, where permanent pastures are more common and larger.

Many soils in this association are subject to erosion. Some areas need artificial drainage. The irregular pattern of slopes makes the application of conservation practices, such as contouring and terracing, somewhat more difficult than in other areas of the county. These practices are used, however. Some of the minor soils are droughty.

Considerable amounts of grain are sold for cash in this area, but most farms are of the general type on which some livestock is raised. The raising and feeding of hogs and the feeding of cattle are the most important livestock enterprises, and cow-calf herds, dairying, and the raising of sheep and poultry are less important.

The area is served by a network of hard-surfaced and gravelled roads, generally along section lines. Farm fields are generally rectangular in shape.

3. *Marshall-Shelby association*

Gently sloping to strongly sloping, silty and loamy, well drained and moderately well drained soils on uplands

This association is in the northwestern corner of the county. The topography is rolling, and most soils are moderately to strongly sloping. The association is drained by three major northwest-southeast oriented streams and their tributaries. These are the Middle Raccoon and South Raccoon Rivers and Brushy Creek. Generally, in the vallies of these streams, the north- and northeast-facing slopes are steeper than the south- or southwest-facing slopes. The valleys of the Middle Raccoon and South Raccoon Rivers are quite narrow. The valley of Brushy Creek is ½ to ¾ mile wide and is in association 8.

This association makes up about 9 percent of the county. Marshall soils occupy 32 percent of the association; Shelby soils, 20 percent; and minor soils, the remaining 48 percent.

Marshall soils formed in loess. These soils are well drained. They have a surface layer of very dark brown to very dark grayish-brown light silty clay loam and a subsoil of brown silty clay loam. They are on ridgetops and side slopes throughout the association and, in a few places, are on benches along streams.

Shelby soils formed in glacial till. These soils are moderately well drained. They typically have a surface layer of very dark brown or dark brown loam. The subsoil is brown clay loam that is typically firm. They are on side slopes below the Marshall soils.

The minor soils of this association are of the Adair, Clarinda, Gara, Hesch, Judson, Ladoga, Lamoni, and Montieth series. Other minor soils are of the Colo and Kennebec series.

Gara soils are loamy and formed under a vegetation of grasses and trees. They are mainly on valley slopes on the south side of the Middle Raccoon and South Raccoon Rivers. Ladoga soils are silty, loess-derived soils that also formed under grass and trees. The Hesch and Montieth soils are sandy to loamy soils that formed in material

weathered from sandstone. They are commonly along the Middle Raccoon River and Brushy Creek. Judson soils are deep, silty soils at the base of slopes. Clarinda, Lamoni, and Adair soils have a clayey subsoil. They are just below the loess-derived soils. Poorly drained Colo soils that are deep, dark-colored silty clay loam and moderately well drained Kennebec soils that are silt loam are along the bottom lands of the South Raccoon and Middle Raccoon Rivers.

The soils in this association are mostly in crops, but some of the rougher areas are commonly in permanent pasture. The main row crop is corn, but soybeans are also grown. Oats and rotation hay and pasture crops, including alfalfa and alfalfa-grass mixtures, are also commonly grown.

The soils on uplands are subject to runoff and erosion. The soils on bottom lands are subject to flooding of varying frequency.

The farms in this association are of the general type, where livestock is raised. Much of the grain is fed to livestock, but some is sold for cash. Hog raising and cattle feeding are the most common livestock enterprises, but cow-calf herds are also raised for beef. There are a few dairy cows, and sheep and poultry are a source of income on some farms.

In this association the pattern of roads reflects the landscape to some extent. In several places roads parallel streams or waterways, and in a number of places roads are lacking because there are no bridges over the three major streams in the association. Most of the roads in the association are hard surfaced or gravelled. Field boundaries deviate from the rectangular pattern in many places. Contoured and terraced fields are common, and field boundaries often follow the contour.

4. Gara-Lindley association

Strongly sloping to very steep, loamy, moderately well drained soils on uplands

This association (fig. 2) is along the Middle Raccoon River and along deeply incised streams flowing easterly and northeasterly into the South Raccoon River. One area extends from the eastern side of the county to the middle of Highland Township. Valley slopes are occupied mainly by steep or very steep soils that formed in glacial till and residual material. Ridgetops are occupied mainly by soils derived from loess.

Bottom lands in the association are only about one-eighth of a mile wide. They are along the Middle Raccoon River and generally are not suited to crops. The bottom lands along the tributaries of the South Raccoon River are about one-fourth of a mile wide and are generally used for row crops. There are areas of soils that formed in residual material along every stream in the association. Soils derived from shale are chiefly in the east and southeast. Soils derived from sandstone are mostly in the central and northwestern parts of the association.

This association makes up about 14 percent of the county. Gara soils occupy about 40 percent of the association; Lindley soils, about 9 percent; and minor soils, the remaining 51 percent.

Gara soils formed in glacial till under grass and trees. These soils have a surface layer of very dark gray loam and a thin subsurface layer of dark grayish-brown loam. The subsoil is firm, dark yellowish-brown and yellowish-brown clay loam. Gara soils are in all parts of the association on valley slopes.

Lindley soils formed in glacial till under trees. These soils have a thin surface layer of very dark gray loam. The subsurface layer is dark grayish-brown to grayish-brown loam. The subsoil is firm clay loam that is brown, dark yellowish brown, and yellowish brown and is mottled with grayish brown and strong brown in the lower part. The soils on valley slopes of the Middle Raccoon River are consistently steep from the town of Panora southeastward to the county line, more than in other parts of the association. Lindley soils are dominant in this area. Outcrops of limestone and shale are common on the lower parts of the slopes. There are discontinuous areas of Lindley soils in most parts of the association. They occupy the steepest, most dissected parts of the landscape.

The minor soils of this association consist of Ladoga soils on most ridgetops; Lester, Clanton, and Storden soils on uplands; Nodaway, Spillville, Kennebec, Colo, and Zook soils on bottom lands; and Hesch, Montieth, Clanton, and Gosport soils on the lower parts of slopes along stream valleys.

Ladoga soils are the most extensive of the minor soils. They are silty and formed in loess. The sloping, loamy Lester soils and the calcareous, loamy Storden soils are north of the Middle Raccoon River. The silty Clinton soils formed under trees in a few places in the southeastern part of the county. The stratified Nodaway soils are adjacent to streams; they are mainly silt loam. Spillville soils are deep, dark colored, and loamy. Kennebec soils are similar to Spillville soils, but are silty. Colo and Zook soils are poorly drained. Zook soils are higher in clay content than Colo soils. Clinton and Gosport soils are clayey soils that formed in material weathered from shale. Hesch and Montieth soils are sandy or loamy soils that formed in material weathered from sandstone.

The steepest parts of this association are generally wooded. Some areas are managed for timber production, but most are used for woodland pasture. Permanent bluegrass pastures are also common. The most important management needs are the control of erosion and the efficient use of permanent pasture and woodland.

Areas of this association are suitable for crops. The main row crop is corn, but soybeans are a common crop on bottom lands. Oats and hay and pasture crops, including alfalfa and alfalfa-grass mixtures, are also grown.

The upland areas of this association are subject to severe sheet and gully erosion. Many areas of bottom lands are subject to flooding.

The farms in this association are used mainly for production of livestock and livestock products. Some grain is produced as a cash crop. Hog raising, cattle feeding, and cow-calf herds are important. There are a few dairy herds, and some farmers keep poultry and sheep.

Many of the roads in this association parallel streams, and a few are on ridgetops. Field and pasture boundaries are more irregular in shape than in other associations. Cultivated fields are mainly on ridgetops and on bottom lands. Some of the fields are small.

***Figure 2.*—Typical landscape in the Gara-Lindley association. Ladoga or Clinton soils are on ridgetops; Gara and Lindley soils are mainly on the side slopes.**

5. Sharpsburg association

Gently sloping and moderately sloping, silty, moderately well drained soils on uplands

This association is in the east-central, southeastern, west-central, and southwestern parts of the county. It is the second largest association in the county. It includes the headwaters of two rivers and many creeks. Several streams feeding into rivers that flow to the Missouri River have their headwaters in this association. In western Guthrie County the association includes part of the Missouri-Mississippi divide that is occupied by gently sloping loess soils.

This association makes up about 20 percent of the county. Sharpsburg soils occupy 60 percent of the association, and minor soils, the remaining 40 percent.

Sharpsburg soils, formed in loess under a vegetation of native grasses, are well drained. They have a surface layer of very dark brown silty clay loam. The subsoil is firm silty clay loam that is brown in the upper part and mottled light brownish gray, yellowish brown, and strong brown in the lower part. Sharpsburg soils are mainly gently sloping on divides and moderately sloping on side slopes.

The minor soils are of the Macksburg, Clearfield, Adair, Clarinda, and Shelby series. Colo soils and the Colo-Judson complex are in waterways and on bottom lands. Macksburg soils are nearly level, silty soils that are somewhat poorly drained. They are on upland divides. The silty, somewhat poorly drained Clearfield soils are in coves where side-valley waterways are numerous. The poorly drained Clarinda soils have a clayey subsoil and are in small areas on side slopes and coves on many farms. Moderately well drained Shelby soils and moderately well drained to somewhat poorly drained Adair soils are also in small areas on many farms. They are

downslope from the other soils on uplands, and upslope from those in stream valleys and drainageways. Colo soils are deep, dark colored, and poorly drained. They are in bottom lands and in many places are closely intermingled with the moderately well drained Judson soils.

The soils in this association are used mainly for crops. A few areas are in permanent pasture. Corn, soybeans, oats, and hay and pasture crops are also grown. The nearly level and gently sloping soils are row cropped intensively.

In this association sheet erosion is more of a hazard than gully erosion. Where Clarinda and Adair soils outcrop, seepy areas are common. The use of interceptor tile in the more permeable loess soils upslope is a common practice.

The farms in this association are mostly of the general type. Most farmers keep livestock, but on some farms cash grain is a larger source of income. Raising hogs and feeding beef cattle are the main livestock enterprises. There are numerous beef cow-calf herds. On a few farms dairy herds are kept. Some sheep and poultry are raised, but they are generally not the main source of income.

The association is served by a network of roads that generally are along section lines. In some places they are along half-mile lines or in other places. Most of those that serve farmsteads are hard surfaced or gravelled.

6. Sharpsburg-Ladoga-Shelby association

Gently sloping to moderately steep, silty and loamy, moderately well drained soils on uplands

This association is mainly in the central and west-central parts of the county, but it also is in the southeastern part. It is the largest association in the county. In this association a very few broad divides between large streams are occupied by gently sloping soils and many divides are occupied by moderately sloping soils. Ridgetops are generally occupied by strongly sloping soils. These soils formed in loess (fig. 3). Strongly sloping to steep soils on side slopes formed in glacial till.

Figure 3.—**Landscape in the Sharpsburg-Ladoga-Shelby association. Sharpsburg soils occupy most of this landscape; Shelby soils are in the foreground and on lower parts of the slopes.**

Except for areas along Middle River where the bottom lands are ⅛ to ¼ mile wide, the bottom lands are generally less than one-eighth mile wide. Sidehill drains and gullies are common (fig. 4).

There are numerous areas of soils formed in sandstone along Brushy Creek and the South Raccoon River. About three-fourths of this association is drained by Brushy Creek and the South Raccoon River. Much of the southern part is drained by the Middle River, and a small amount in the northern part is drained by the Middle Raccoon River. South- and southwest-facing slopes tend to be less steep than north- and northeast-facing slopes. North- and northeast-facing slopes are more likely to have trees growing on them and to be occupied by soils that formed under a native vegetation that included trees.

This association makes up about 25 percent of the county. Sharpsburg soils occupy about 30 percent of the association; Ladoga soils, about 25 percent; Shelby soils, about 20 percent; and minor soils, the remaining 25 percent.

Sharpsburg soils formed in loess under a vegetation of prairie grasses. These soils have a surface layer of very dark brown silty clay loam. The subsoil is firm silty clay loam that is brown in the upper part and mottled light brownish gray, yellowish brown, and strong brown in the lower part. Sharpsburg soils in this association are mainly moderately sloping on ridgetops and side slopes, but they are also gently sloping on some ridgetops or strongly sloping on side slopes.

Ladoga soils formed in loess under a native vegetation of prairie grasses and trees. These soils have a surface

Figure 4.—Gully control structure in the Sharpsburg-Ladoga-Shelby association.

layer of very dark gray silt loam and a subsurface layer of very dark grayish-brown to dark grayish-brown silt loam that has platy structure. The subsoil is brown and yellowish-brown silty clay loam that is mottled with gray in the lower part. Ladoga soils are mainly strongly sloping on side slopes but are also moderately sloping on ridgetops.

Shelby soils formed in glacial till. These soils are loamy. They are mainly moderately steep on side slopes. Where they are closely intermingled with Adair soils, they are strongly sloping and moderately steep.

Minor soils are the Gara, Hesch, Montieth, Clarinda, Adair, and Lamoni soils and Dickinson-Sharpsburg complex on uplands; the Judson, Ely, and Olmitz soils on foot slopes; and the Colo and Zook soils on bottom lands.

Hesch and Montieth soils are sandy or loamy soils that formed in sandstone, and they are along Brushy Creek and the South Raccoon River. Clarinda, Adair, and Lamoni soils have a clayey subsoil and are downslope from loess-derived soils and upslope from Shelby soils. Areas of the closely intermingled Dickinson and Sharpsburg soils are on the east side of Middle River, the South Raccoon River, and Brushy Creek. Dickinson soils are loamy, and Sharpsburg soils are silty. The moderately well drained Judson soils and somewhat poorly drained Ely soils are silty. Olmitz soils are loamy. Colo and Zook soils are deep, dark colored, and poorly drained. Zook soils are similar to Colo soils, except that they are more clayey.

Suitable soils in this association are used for crops, but a large acreage is in permanent pasture. The main row crop is corn. Soybeans are grown mainly on the bottom lands of the Middle River and on the less sloping areas of the association. Oats and hay and pasture crops, including alfalfa and alfalfa-grass mixtures, are also grown on a considerable acreage.

The soils in this association are subject to sheet erosion and gullying. Uncrossable gullies are common where waterways slope much more than 3 percent. Good pasture management is important in this area if the large acreage of permanent pasture is to be fully utilized.

Most farms in this association are of the general type, but livestock production is emphasized. Raising cow-calf herds for beef, cattle feeding, and hog raising are all important. A number of dairy herds are in the area. More poultry is kept than in other associations, but this is not a major source of income on most farms.

The roads are mainly along section lines, but in many places they parallel streams or follow ridgetops. Almost all roads that serve farmsteads are hard surfaced or gravelled.

7. *Sharpsburg-Macksburg association*

Nearly level to gently sloping, silty, moderately well drained and somewhat poorly drained soils on uplands

This association is in the southeastern corner of the county. It is mainly on the wide, gently sloping divide between the South Raccoon River and the North River. It is also in a small area between the Middle Raccoon and South Raccoon Rivers. It is the smallest soil association in the county.

This association makes up about 2 percent of the county. Sharpsburg soils occupy 60 percent of the association; Macksburg soils, about 15 percent; and minor soils, the remaining 25 percent.

Sharpsburg soils formed in loess under a vegetation of prairie grasses. These soils are moderately well drained. They have a surface layer of very dark brown silty clay loam. The subsoil is silty clay loam that is brown in the upper part and mottled light brownish gray, yellowish brown, and strong brown in the lower part.

Macksburg soils formed in loess under a vegetation of prairie grasses. They have a fairly thick surface layer of silty clay loam that is black in the upper part and very dark gray in the lower part. The subsoil is dark grayish-brown silty clay loam.

Minor soils are the poorly drained, dark-colored Colo soils in drainageways and a few areas of Clarinda soils that are poorly drained, have a clayey subsoil, and are in coves.

The soils of this association are mainly used for crops. Only a few areas are in permanent pasture. The main row crops, corn and soybeans, are generally grown on nearly level and gently sloping soils. Some oats and rotation hay and pasture crops, including alfalfa and alfalfa-grass mixtures, are also grown (fig. 5).

The sloping areas of this association are subject to erosion, especially if they are intensively row cropped. The maintenance of soil tilth and fertility is important. Most areas have adequate drainage, but tile drainage is needed for the waterways that have their headwaters in the nearly level areas of the broad divides.

The soils in this association generally are fairly intensively row cropped. A considerable amount of grain is sold. Livestock, mainly hogs and beef cattle, are raised. Not many farms are wholly within this association.

8. *Zook-Colo-Vesser association*

Nearly level, silty, poorly drained soils on bottom lands

This association includes bottom lands that are generally one-third mile or more wide. It occupies bottom lands along the South Raccoon River and Brushy Creek (fig. 6).

This association makes up about 5 percent of the county. Zook soils occupy about 30 percent of the association; Colo soils, about 10 percent; Vesser soils, about 10 percent; and minor soils, the remaining 50 per cent.

Zook soils have a thick surface layer of black silty clay loam. The subsoil is very dark gray heavy silty clay loam. Colo soils are silty clay loam and typically are black to a depth of 3 feet or more. Many areas of Colo and Zook soils have a few inches of moderately dark silt loam overwash. In places Colo soils occupy the entire bottom. On wider bottoms they are typically between areas of Zook soils and Nodaway soils or Alluvial land, near streams.

Vesser soils have a surface layer of black and very dark gray silt loam. The subsurface layer is dark-gray silt loam that is distinctly lighter colored when dry. The subsoil is dark-gray and gray light silty clay loam. Vesser soils are generally on bottom lands that have poor surface drainage or on low benches in the stream valleys.

The minor soils are of the Nodaway, Kennebec, and Nevin series; also in this association is Alluvial land.

Nodaway soils occupy a number of fairly large areas in the association, but they are not so extensive as the major soils. They consist of moderately well drained,

Figure 5.—**Soybeans growing on Macksburg silty clay loam.**

light-colored silt loam that has occasional strata of very fine sandy loam or other textures. In some places there is a dark-colored, buried soil at a depth below 3 feet. Alluvial land typically consists of stratified sand and silty materials. Alluvial land and Nodaway soils are typically near streams and are subject to flooding more often than other soils on bottoms. Kennebec soils are moderately well drained and are on first bottoms. Nevin soils are somewhat poorly drained, silty soils on benches.

The soils in this association are mainly used for crops, but some inaccessible areas or areas that are frequently flooded or cut up by old stream channels are in pasture. The major row crop is corn, but soybeans and some oats and hay are also grown.

Most soils on first bottoms are subject to some flooding. Flooding generally occurs early enough in spring or is of short enough duration that crops can be grown. Tile drainage is needed in many areas of the Zook and Colo soils. In some places it is difficult to maintain adequate outlets for tile drainage.

Only a few farms are wholly within this association, and most farms also include some soils on uplands.

In many places roads are along the edge of this association. Roads cross the association where the major streams are bridged at about 3-mile intervals.

Descriptions of the Soils

In this section the soil series and mapping units represented in this county are described. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

The soils of each series are first described as a group. Important features common to all the soils of the series are listed, and the position of the soils on the landscape is given. Each series description has a short narrative description of a representative profile and a much more detailed description of the same profile, from which highly technical interpretations can be made. Following

Figure 6.—**Bottom lands along Brushy Creek. Water standing on Zook soils in foreground; trees growing on Colo soils and Alluvial land in background.**

the profile is a brief statement of the range of characteristics of the soils in the series as mapped in this county. Comparisons are made with other soils that are nearby or are generally similar to the soils of the series being described.

Each soil, or mapping unit, in the series is next described. Mapping units are the areas delineated on the map and identified by soil symbols. Generally these descriptions tell how the profile of the soil differs from that described as representative of the series. They also tell about the use and suitability of the soil described and something about management needs.

For full information about any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. General information about the broad patterns of soils in the county is given in the section "General Soil Map." The color names and color symbols given are for a moist soil unless otherwise indicated.

Adair Series

The Adair series consists of deep, moderately dark colored, moderately well drained to somewhat poorly drained soils on uplands. These soils have a reddish, clayey subsoil. They are on narrow extended ridgetops and side slopes in the southern part of the county. Individual areas range from 3 to 15 acres in size. Slopes range from 9 to 18 percent.

Adair soils formed in parts of an old, reddish, clayey soil that formed during an earlier geologic period. The old soil formed in clay loam glacial till under forest vegetation and was later buried by loess. In time, the loess was removed by geologic erosion and new soils began to form. The remaining old, reddish, clayey layers became the subsoil of the newly formed Adair soils. Beneath this subsoil is clay loam glacial till 20 to more than 50 feet thick. The native vegetation was prairie grasses.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Adair clay loam, 9 to 14 percent slopes, moderately eroded	610	0.2
Adair clay loam, 14 to 18 percent slopes, moderately eroded	225	.1
Adair soils, 14 to 18 percent slopes, severely eroded	221	.1
Alluvial land	3,881	1.0
Calco silty clay loam	176	(1)
Canisteo silty clay loam	4,570	1.2
Clanton silt loam, 18 to 30 percent slopes	288	.1
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	240	.1
Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	1,333	.4
Clarion loam, 2 to 5 percent slopes	24,437	6.4
Clarion loam, 2 to 5 percent slopes, moderately eroded	927	.2
Clarion loam, 5 to 9 percent slopes	4,572	1.2
Clarion loam, 5 to 9 percent slopes, moderately eroded	4,369	1.1
Clarion loam, 9 to 14 percent slopes, moderately eroded	1,657	.4
Clarion loam, 14 to 18 percent slopes	369	.1
Clearfield silty clay loam, 9 to 14 percent slopes, moderately eroded	483	.1
Clinton silt loam, 2 to 5 percent slopes	306	.1
Clinton silt loam, 5 to 9 percent slopes, moderately eroded	846	.2
Clinton silt loam, 9 to 14 percent slopes, moderately eroded	615	.1
Clinton soils, 9 to 14 percent slopes, severely eroded	309	.1
Colo silty clay loam, 0 to 2 percent slopes	3,599	.9
Colo silty clay loam, 2 to 5 percent slopes	1,692	.4
Colo silt loam, channeled, 0 to 2 percent slopes	4,158	1.1
Colo silt loam, overwash, 0 to 2 percent slopes	7,584	2.0
Colo silt loam, overwash, 2 to 5 percent slopes	3,054	.8
Colo-Judson complex, 2 to 5 percent slopes	13,431	3.5
Colo-Spillville complex, 2 to 5 percent slopes	552	.1
Colo-Spillville complex, channeled, 2 to 5 percent slopes	342	.1
Cylinder loam	799	.2
Dickinson-Sharpsburg complex, 5 to 9 percent slopes, moderately eroded	240	.1
Dickinson-Sharpsburg complex, 9 to 14 percent slopes, moderately eroded	712	.2
Ely silty clay loam, 2 to 5 percent slopes	1,051	.3
Gara loam, 9 to 14 percent slopes, moderately eroded	1,521	.4
Gara loam, 14 to 18 percent slopes, moderately eroded	8,081	2.1
Gara loam, 18 to 25 percent slopes, moderately eroded	14,844	3.9
Gara loam, 25 to 40 percent slopes, moderately eroded	277	.1
Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded	4,917	1.3
Gosport silt loam, 9 to 18 percent slopes, moderately eroded	304	.1
Gosport silt loam, 18 to 30 percent slopes, moderately eroded	1,456	.4
Harps loam	133	(1)
Hesch sandy loam, 9 to 18 percent slopes	464	.1
Hesch loam, 9 to 14 percent slopes	612	.2
Hesch loam, 14 to 18 percent slopes	912	.2
Humeston silt loam	100	(1)
Judson silty clay loam, 2 to 5 percent slopes	2,298	.6
Judson silty clay loam, 5 to 9 percent slopes	830	.2
Kennebec silt loam	842	0.2
Ladoga silt loam, 0 to 2 percent slopes	196	(1)
Ladoga silt loam, 2 to 5 percent slopes	1,795	.5
Ladoga silt loam, 5 to 9 percent slopes	663	.2
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	15,441	4.1
Ladoga silt loam, 9 to 14 percent slopes	523	.1
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	10,997	2.9
Ladoga silt loam, 14 to 18 percent slopes, moderately eroded	689	.2
Ladoga silt loam, benches, 2 to 5 percent slopes	584	.2
Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	904	.3
Lamoni silty clay loam, 14 to 18 percent slopes, moderately eroded	483	.1
Lester loam, 2 to 5 percent slopes	417	.1
Lester loam, 5 to 9 percent slopes, moderately eroded	798	.2
Lester loam, 9 to 14 percent slopes, moderately eroded	569	.1
Lindley loam, 14 to 18 percent slopes, moderately eroded	888	.2
Lindley loam, 18 to 25 percent slopes, moderately eroded	976	.3
Lindley loam, 25 to 40 percent slopes, moderately eroded	2,818	.7
Lindley soils, 18 to 25 percent slopes, severely eroded	485	.1
Macksburg silty clay loam	1,159	.3
Marsh	605	.2
Marshall silty clay loam, 2 to 5 percent slopes	813	.2
Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	5,250	1.4
Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	4,668	1.2
Marshall silty clay loam, benches, 2 to 5 percent slopes	464	.1
Montieth loamy sand, 9 to 14 percent slopes	532	.1
Montieth loamy sand, 14 to 18 percent slopes	1,634	.4
Montieth loamy sand, 18 to 30 percent slopes	2,979	.8
Nevin silty clay loam	1,663	.4
Nicollet loam, 1 to 3 percent slopes	15,294	4.0
Nodaway silt loam	3,041	.8
Nodaway silt loam, channeled	961	.2
Okoboji silty clay loam	338	.1
Olmitz loam, 2 to 5 percent slopes	2,930	.8
Olmitz loam, 5 to 9 percent slopes	2,444	.7
Olmitz-Colo complex, channeled, 2 to 7 percent slopes	11,071	2.9
Salida sandy loam, 7 to 14 percent slopes, moderately eroded	378	.1
Sharpsburg silty clay loam, 0 to 2 percent slopes	1,045	.3
Sharpsburg silty clay loam, 2 to 5 percent slopes	10,749	2.8
Sharpsburg silty clay loam, 5 to 9 percent slopes	2,572	.7
Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded	37,882	9.9
Sharpsburg silty clay loam, 9 to 14 percent slopes	331	.1
Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded	25,494	6.7
Sharpsburg silty clay loam, 14 to 18 percent slopes, moderately eroded	454	.1
Sharpsburg silty clay loam, benches, 2 to 5 percent slopes	1,306	.3

See footnote at end of table.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Acres	Percent	Soil	Acres	Percent
Shelby loam, 2 to 5 percent slopes	513	0. 1	Storden loam, 9 to 14 percent slopes, moderately eroded	1, 441	0. 4
Shelby loam, 5 to 9 percent slopes, moderately eroded	382	. 1	Storden loam, 14 to 18 percent slopes, moderately eroded	616	. 2
Shelby loam, 9 to 14 percent slopes, moderately eroded	10, 156	2. 7	Storden loam, 18 to 25 percent slopes, moderately eroded	477	. 1
Shelby loam, 14 to 18 percent slopes, moderately eroded	13, 344	3. 5	Vesser silt loam, 0 to 2 percent slopes	1, 185	. 3
Shelby loam, 18 to 25 percent slopes, moderately eroded	4, 798	1. 3	Vesser silt loam, overwash, 0 to 2 percent slopes	966	. 3
Shelby soils, 14 to 18 percent slopes, severely eroded	742	. 2	Wadena loam, deep, 0 to 2 percent slopes	409	. 1
Shelby soils, 18 to 25 percent slopes, severely eroded	343	. 1	Wadena loam, deep, 2 to 5 percent slopes	804	. 2
Shelby-Adair complex, 9 to 14 percent slopes, moderately eroded	8, 539	2. 2	Wadena loam, deep, 5 to 14 percent slopes	264	. 1
Shelby-Adair complex, 9 to 14 percent slopes, severely eroded	294	. 1	Wadena loam, moderately deep, 0 to 2 percent slopes	144	(1)
Shelby-Adair complex, 14 to 18 percent slopes, moderately eroded	6, 338	1. 7	Wadena loam, moderately deep, 2 to 5 percent slopes	901	. 2
Shelby-Adair complex, 14 to 18 percent slopes, severely eroded	1, 917	. 5	Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	289	. 1
Spillville loam, 1 to 3 percent slopes	376	. 1	Webster silty clay loam	14, 097	3. 7
Storden loam, 5 to 9 percent slopes, moderately eroded	879	. 2	Zook silt loam, overwash	2, 112	. 6
			Zook silty clay loam	2, 995	. 8
			Streams, ponds, gravel pits and others	5, 597	1. 5
			Total	381, 440	100. 0

[1] Less than 0.05 percent.

In a representative profile, the surface layer is very dark gray clay loam about 11 inches thick. In eroded areas this layer is somewhat thinner. The subsoil extends to a depth of about 47 inches. The upper part of the subsoil, to a depth of 14 inches, is brown clay loam and, to a depth of 27 inches, is yellowish-red and brown light to medium clay that contains mottles of strong brown and dark red. The lower part of the subsoil is mottled yellowish-brown, dark yellowish-brown, and light olive-gray, firm clay loam. The substratum is similar to the lower part of the subsoil, but is calcareous.

The Adair soils have high available water capacity. They are slowly permeable. The water table is generally at a depth below 5 feet, but during periods of heavy rainfall the soils are seepy and wet. When dry, the subsoil cracks and becomes hard. The surface layer is slightly acid to medium acid unless limed. These soils are low in content of available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Adair soils that are on slopes of less than 14 percent are suited to row crops. The more sloping soils are suited to pasture and woodland. These soils are susceptible to erosion and gullying if vegetation is sparse. The clayey subsoil limits root growth.

Adair soils are in small areas and generally are managed along with the adjacent soils. Some areas are so small that they are mapped as a complex with the Shelby soils.

Representative profile of Adair clay loam, 9 to 14 percent slopes, moderately eroded, 429 feet west and 222 feet south of the northeast corner of SE¼ sec. 6, T. 78 N., R. 32 W. on a convex, southeast-facing slope:

Ap—0 to 7 inches, very dark gray (10YR 3/1) clay loam; cloddy breaking to weak, fine, subangular structure; friable; slightly acid; abrupt, smooth boundary.

A3—7 to 11 inches, very dark gray (10YR 3/1) mixed with 25 percent dark grayish-brown (10YR 4/2) light clay loam; few dark yellowish-brown (10YR 4/4) peds in lower part of horizon; weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B1—11 to 14 inches, brown (10YR 4/3 to 7.5YR 4/4) medium clay loam; weak, fine, subangular blocky structure; friable; a few very dark (10YR 3/1) worm casts and fills in old root channels; stoneline with pebbles up to 1 inch in diameter at base of horizon; slightly acid; abrupt, smooth boundary.

IIB21t—14 to 17 inches, yellowish-red (5YR 4/6) and brown (7.5YR 4/4) light to medium clay; few, fine, strong-brown (7.5YR 5/8) mottles; moderate, fine and very fine, subangular blocky structure; firm; thin discontinuous clay films; few pebbles; medium acid; clear, smooth boundary.

IIB22t—17 to 21 inches, brown (7.5YR 4/4) light to medium clay, dark brown (7.5YR 4/4) when kneaded; common, fine, strong-brown (7.5YR 5/8) mottles and few, fine, dark-red (2.5YR 3/6) mottles; strong, very fine, subangular blocky structure; firm; thin continuous clay films; medium acid; clear, smooth boundary.

IIB23t—21 to 27 inches, brown (7.5YR 4/4) light clay; few, fine, dark-red (2.5YR 3/6) mottles and common, fine, strong-brown (7.5YR 5/8) mottles; moderate, fine and very fine, subangular blocky structure; firm; thin discontinuous clay films on horizontal faces of peds and somewhat continuous clay films on vertical faces; slightly acid; gradual, smooth boundary.

IIB31t—27 to 33 inches, yellowish-brown (10YR 5/4) and dark yellowish-brown (10YR 4/4) heavy clay loam; few, fine, strong-brown (7.5YR 5/8) mottles and few, fine, light olive-gray (5Y 6/2) mottles; moderate, medium, prismatic structure breaking to weak, medium, subangular blocky; firm; thin, discontinuous, brown clay films; slightly acid; clear, smooth boundary.

IIB32t—33 to 47 inches, mottled light olive-gray (5Y 6/2) and yellowish-brown (10YR 5/4) medium clay loam, yellowish brown dominant at a depth below 44 inches; few, fine, yellowish-brown (10YR 5/8) mottles; weak, medium, prismatic structure breaking

to weak, medium, subangular blocky; firm; thin, discontinuous, dark grayish-brown clay films; some brownish-yellow oxides and many very fine black oxides at depths between 34 and 37 inches; neutral.

IIC—47 to 60 inches, mottled yellowish-brown (10YR 5/6) and light olive-gray (5Y 6/2) medium clay loam; massive, some vertical cleavage; firm; few oxides; mildly alkaline; strongly effervescent.

The surface layer is 10 to 14 inches thick unless eroded. It is black, very dark gray, or very dark grayish-brown loam to light clay loam. If the subsoil is brown, dark yellowish brown, or yellowish brown, mottles of yellowish red and dark red are visible. If the subsoil is red, the mottles are yellowish. The reddish color or mottles decrease as depth increases. The clayey part of the subsoil is 1 to 1½ feet thick. The surface layer and upper part of the subsoil are medium acid to slightly acid. Carbonates are at depths between 3½ and 5 feet in the lower part of the subsoil and in the substratum.

Adair soils have a brownish subsoil with red mottles, but Clarinda and Lamoni soils have a grayish subsoil. They have a thinner clayey subsoil than Clarinda soils. These soils have a thicker surface layer than Armstrong soils. They also lack the dark grayish-brown subsurface layer and are generally not so acid as Armstrong soils.

Adair clay loam, 9 to 14 percent slopes, moderately eroded (192D2).—Most of this soil is in narrow bands at the shoulder of side slopes, and few areas are on the lower slopes of extended ridges. It is upslope from the Shelby soils and downslope from the Sharpsburg, Ladoga, or Clinton soils. Individual areas are generally small. This soil has the profile described as representative for the series.

Included in mapping are areas that have a thinner surface layer, and where plowing has exposed the brownish and reddish subsoil in places. Large areas where the soil is exposed are shown on the soil map by a symbol for severe erosion. About 190 acres have slopes of 5 to 9 percent. A few soils similar to the Armstrong and Lamoni soils are also included.

Erosion and occasional wetness from seepage are hazards. When saturated, this soil dries out slowly. During periods of low rainfall the subsoil dries out hard and cracks appear. In some places where this soil is on side slopes, a narrow wet band is near the boundary of the adjacent soils upslope. Interceptor tile placed in the more permeable soils above reduces wetness. Runoff is rapid, and in plowed areas erosion is a serious hazard.

Much of this soil is cultivated. It is generally managed along with the steeper Shelby soils downslope. This soil is poorly suited to row crops even if erosion and wetness are controlled. (Capability unit IVe-1; woodland suitability group 7)

Adair clay loam, 14 to 18 percent slopes, moderately eroded (192E2).—This soil is in narrow bands at the upper part of the side slopes. It is also in areas that form the head slopes of drainageways. This soil is upslope from Shelby and Gara soils and downslope from Sharpsburg, Ladoga, and Clinton soils. Individual areas are generally small in size. This soil has a profile similar to the one described as representative, except that the surface layer is very dark grayish brown and thinner. Also, most of this soil has a thinner, clayey subsoil, and carbonates occur at a depth of 3 to 4 feet.

Included with this soil in mapping are a few areas that have stratified, loamy, erosional sediments in the lower part of the subsoil and substratum. Also included are a few small areas that have a grayer subsoil and places where plowing has exposed the brownish and reddish subsoil.

Erosion is a severe hazard. When saturated, this soil dries out slowly. It dries out hard and cracks appear. In places on head slopes and side slopes a narrow wet band is near the boundary of the adjacent soils upslope. Interceptor tile in the more permeable soils above reduces wetness.

Much of this soil has been cultivated in the past, but it is now commonly in pasture or idle. It is managed along with the steeper Shelby and Gara soils downslope. It is suited to pasture and woodland. (Capability unit VIe-1; woodland suitability group 7)

Adair soils, 14 to 18 percent slopes, severely eroded (192E3).—These soils are at the upper part of side slopes and on head slopes of drainageways. They are associated with other Adair soils on similar slopes. Sharpsburg and Ladoga soils are upslope, and Shelby and Gara soils are downslope. Individual areas are 5 to 20 acres in size. These soils have a slightly thinner, more clayey subsoil than that in the profile described as representative. Carbonates are at a depth of 3 to 4 feet.

Included with these soils in mapping are places where the reddish and brownish clay loam or clay subsoil is exposed on the surface. Also included are some areas that have a very thin, dark-brown or very dark grayish-brown, clay loam surface layer. Also included are a few small areas that have a grayer subsoil.

Erosion and low fertility limit the use of these soils. The surface layer dries out hard and cracks appear. Tilth is poor. A narrow seepy band occurs where these soils adjoin the Sharpsburg or Ladoga soils upslope during wet periods.

Some of the acreage is cultivated. It is suited to pasture, woodland, or habitat for wildlife. The soils have limited use for pasture. It is difficult to establish seedings in idle areas. Most areas are managed along with the adjacent, less eroded Adair soils or Shelby soils downslope. Most areas are too small to be managed separately. (Capability unit VIIe-1; woodland suitability group 7)

Alluvial Land

Alluvial land (0 to 2 percent slopes) (315) consists of stratified sandy and silty soils formed in material deposited along major rivers and streams by frequent flooding. These undulating but nearly level soils on first bottoms are dissected by oxbows and meandering stream channels. Individual areas vary in size, but most are narrow and parallel the major rivers and streams.

Alluvial land is extremely variable in content of sand, silt, or clay. Permeability, available water capacity, and natural fertility are also variable. No distinct soil profile has formed. Sandy sediments that contain layers of silt and clay range from 2 feet to many feet in thickness. The low spots in the undulating landscape are generally more clayey than the higher areas. This land type is adjacent to the Nodaway and the Colo, overwash, soils.

Included with this land type in mapping are some areas of soils that are frequently flooded.

Much of this land type is wet during periods of high rainfall. New sediments are deposited during periods of flooding, and water stands for several months in old

bayous or depressions. The sandy areas are droughty in midsummer and late in summer. The vegetation consists of water-tolerant trees and grasses.

Little of this land type is cultivated. Most of the acreage is used as woodland or for permanent pasture. Some areas can be used for row crops if they are diked to prevent flooding, cleared of willow brush and scrub timber, and leveled. Streambank cutting is a hazard in areas that have been cleared but not protected from flooding. (Capability unit Vw-1; woodland suitability group 9)

Armstrong Series

The Armstrong series consists of deep, moderately dark colored, moderately well drained to somewhat poorly drained soils on uplands. They are closely associated with the Gara soils, and in this county they occur in the Gara-Armstrong complex. Gara-Armstrong soils are on irregular, convex side slopes. Individual areas range from about 5 to 15 acres. Slopes range from 14 to 18 percent.

Armstrong soils formed in parts of an old, reddish, clayey soil that formed during an earlier geologic period. The old soil formed in clay loam glacial till under forest vegetation. It later was buried by loess. In time, the loess was removed by geologic erosion and new soils began to form. The remaining old, reddish, clayey layers became the subsoil of the newly formed Armstrong soils. Beneath the clayey subsoil is clay loam glacial till 20 to more than 50 feet thick. The native vegetation of the Armstrong soils was trees and prairie grasses.

In a representative profile, the surface layer is black and very dark gray loam about 8 inches thick. The subsurface layer is dark grayish-brown, friable loam about 4 inches thick. This layer is distinctly light colored when dry. The upper part of the subsoil, to a depth of about 31 inches, is brown, reddish-brown, strong-brown, and yellowish-brown, firm heavy clay loam and light clay mottled with reddish brown, brown, yellowish red, and grayish brown. The lower part of the subsoil is strong-brown, firm clay loam mottled with grayish brown. The substratum, at a depth of 40 inches, is yellowish-brown sandy clay loam mottled with light brownish gray.

Armstrong soils have a high available water capacity. They are slowly permeable. They are medium acid to very strongly acid in the surface layer unless limed. These soils are seepy during wet seasons, but the water table is generally below 5 feet. These soils are very low in content of available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Most areas are in pasture and they are suited to this use. A few trees and shrubs grow along drainageways in areas of pasture. These soils are eroded by runoff if vegetation is sparse. They are seepy, and puddle if worked when wet. Some sidehill drainageways form gullies unless runoff is controlled.

Armstrong soils in the Gara-Armstrong complex are managed along with the Ladoga soils upslope and the Gara soils or Colo-Judson complex downslope.

Representative profile of Armstrong loam, in an area of Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded, 350 feet north and 60 feet west of the southeast corner of NE¼SW¼ sec. 5, T. 78 N., R. 31 W., on a north-facing slope of about 16 percent:

A1—0 to 8 inches, black (10YR 2/1) and very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; weak, medium, platy structure breaking to moderate, fine, granular; friable; slightly acid; clear, smooth boundary.

A2—8 to 12 inches, dark grayish-brown (10YR 4/2) heavy loam, brown (10YR 5/3) when dry; weak, coarse, platy structure breaking to weak, very fine, subangular blocky; friable; light brownish-gray (10YR 6/2) nearly continuous silt coatings; medium acid; clear, smooth boundary.

B1—12 to 16 inches, brown (7.5YR 4/4) heavy clay loam; moderate, very fine, subangular and angular blocky structure; firm; thin, discontinuous, pale-brown (10YR 6/3) silt coatings; stone line in lower part; very strongly acid; clear, smooth boundary.

B21t—16 to 20 inches, reddish-brown (5YR 4/3) and brown (7.5YR 4/4) light clay; strong, very fine, subangular blocky structure; very firm; thick discontinuous clay films; common fine pebbles; very strongly acid; clear, smooth boundary.

B22t—20 to 26 inches, strong-brown (7.5YR 5/6) light clay; common, fine, reddish-brown (5YR 4/3) mottles; weak, medium, subangular blocky structure breaking to moderate, medium, subangular blocky; firm; thick discontinuous clay films; common fine pebbles; very strongly acid; gradual, smooth boundary.

B31t—26 to 31 inches, yellowish-brown (10YR 5/4) heavy clay loam; common, medium, distinct, yellowish-red (5YR 4/6) mottles and few, fine, grayish-brown (10YR 5/2) mottles; moderate, medium, subangular blocky structure; firm; thin discontinuous clay films; dark-gray coatings in root channels; very strongly acid; gradual, smooth boundary.

B32t—31 to 40 inches, strong-brown (7.5YR 5/6) clay loam; few to common, fine, grayish-brown (10YR 5/2) mottles; weak, coarse, subangular blocky structure; firm; few roots and tubular pores; thin, discontinuous, medium clay films; dark-gray organic coatings in root channels; strongly acid; gradual, smooth boundary.

C—40 to 53 inches, yellowish-brown (10YR 5/4) sandy clay loam; many light brownish-gray (2.5Y 6/2) mottles; very weak, coarse, blocky structure to massive; firm; common black oxides; medium acid; gradual, smooth boundary.

The surface layer is black, very dark gray, or very dark grayish-brown, friable loam to gritty silt loam 6 to 10 inches thick. The subsurface layer is dark grayish-brown to grayish-brown, friable loam to gritty silt loam as much as 5 inches thick. In cultivated areas, the subsurface layer is often mixed with the plow layer. The upper part of the subsoil is brown, reddish-brown, yellowish-red, dark reddish-brown, or strong-brown heavy clay loam to light clay with reddish mottles. The firm clay layers are 6 to 18 inches thick. The lower part of the subsoil and the substratum are brown, strong-brown, dark yellowish-brown, and yellowish-brown, firm clay loam or sandy clay loam mottled with light brownish gray, gray, or olive gray. These soils are medium acid to very strongly acid in the upper part of the subsoil and medium acid to mildly alkaline in the substratum. Carbonates are at a depth between 4 and 5 feet.

Armstrong soils have a thinner surface layer, and are generally more acid in the subsoil than Adair soils. They have a dark grayish-brown to grayish-brown subsurface layer that is lacking in the Adair soils. They have redder colors and more clay in the subsoil than Gara soils.

Calco Series

The Calco series consists of deep, dark-colored, poorly drained, silty soils on low parts of first bottoms. Slopes are 0 to 2 percent.

Calco soils formed in silty alluvium 4 to nearly 10 feet thick. Below this are stratified loamy or sandy sediments about 10 to 20 feet thick. The material below this depth is variable, but in moderately wide drainageways many feet of glacial till occur in places below the alluvium.

In a representative profile, the surface layer is black to very dark gray silty clay loam about 34 inches thick. The next layer is very dark gray silty clay loam. It extends to a depth of about 46 inches. Below this, the substratum is dark-gray clay loam. Some grayish-brown and strong-brown mottles are at a depth of about 3 feet and below.

Calco soils have a high available water capacity. They are moderately slowly permeable. The water table is high unless these soils are artificially drained. There is an excess of lime, and the surface layer is moderately alkaline. These soils are medium to low in content of available nitrogen, very low in available phosphorus, and low to very low in available potassium.

Calco soils are wet because of a high water table and flooding. The surface layer puddles easily if worked when wet.

Most Calco soils are drained and used for cultivated crops. Because individual areas are small, they are managed along with the surrounding Colo and Zook soils.

Representative profile of Calco silty clay loam, 63 feet north and 530 feet west of the southeast corner of NW¼ sec. 3, T. 80 N., R. 30 W., on first bottom land that has a slope of 1 percent:

Ap—0 to 8 inches, black (N 2/0) light silty clay loam; cloddy breaking to weak, fine, granular structure; friable; common small shell fragments; strongly effervescent; moderately alkaline; gradual, smooth boundary.

A11—8 to 21 inches, black (N 2/0) medium silty clay loam; weak, fine, subangular blocky structure breaking to medium, fine, granular; friable; common small shell fragments; strongly effervescent; moderately alkaline; diffuse, smooth boundary.

A12—21 to 34 inches, black (N 2/0) to very dark gray (N 3/0) medium to heavy silty clay loam; black (10YR 2/1) when kneaded; weak, coarse, subangular blocky structure breaking to weak, fine, granular; friable; common black (N 2/0) coatings on peds; common fine sand grains; strongly effervescent; mildly alkaline; diffuse, smooth boundary.

AC—34 to 46 inches, very dark gray (N 3/0) to (10YR 3/1) medium silty clay loam; few, coarse, distinct, grayish-brown (2.5Y 5/2) mottles and many, fine, strong-brown (7.5YR 5/6) mottles; very weak, coarse, subangular blocky structure to massive; friable; strongly effervescent; mildly alkaline; clear, smooth boundary.

Cg—46 to 60 inches, dark-gray (N 4/0) light clay loam; massive; friable; strongly effervescent; mildly alkaline.

The surface layer is black or very dark gray, friable light or medium silty clay loam 24 to 36 inches thick. Between the surface layer and substratum, in some areas, is a transitional layer of very dark gray silty clay loam that has enough sand to feel gritty. The substratum ranges from very dark gray or dark gray to olive gray, friable silty clay loam or clay loam. Brown, yellowish-brown, strong-brown, and grayish-brown mottles are at a depth of 30 inches or below. Free carbonates are abundant in all layers. They are mildly alkaline or moderately alkaline.

Calco soils differ from Canisteo soils in that they are silty rather than loamy and are darker colored to a greater depth. They are calcareous, but Colo and Zook soils are not. In addition, Calco soils contain less clay between depths of 10 and 40 inches than Zook soils.

Calco silty clay loam (0 to 2 percent slopes) (733).—This soil is generally in the lowest part of first bottom lands. It is in about the same position as the surrounding Colo and Zook soils, but it is at a slightly lower elevation. Individual areas range from 5 to as much as 20 acres in size.

Included with this soil in mapping are a few areas that are clay loam at a depth below 36 inches. Also included are a few spots that have about 6 to 12 inches of very dark grayish-brown silt loam deposited on the dark surface layer.

This soil has a high water table and floods during periods of high rainfall. It is well suited to row crops if artificially drained and protected from flooding. All of this soil is managed along with the surrounding Colo and Zook soils. (Capability unit IIw-2; woodland suitability group 9)

Canisteo Series

The Canisteo series consists of deep, dark-colored, poorly drained, loamy soils on uplands. Canisteo soils are in the northeastern part of the county. They are in swales or low areas. Slopes range from 0 to 2 percent.

These soils formed in glacial till and sediments from glacial till. Below the glacial sediments is about 20 feet or more of loam glacial till. The native vegetation was grasses and sedges that tolerate excessive wetness.

In a representative profile, the surface layer is black to very dark gray light silty clay loam and clay loam about 24 inches thick. The subsoil extends to a depth of about 38 inches. It is dark-gray and light-olive gray light clay loam and sandy clay loam with yellowish-brown and strong-brown mottles. The substratum is light olive-gray to light-gray, friable loam to sandy clay loam mottled with yellowish brown.

Canisteo soils have high available water capacity. They are moderately permeable. These soils are calcareous throughout. They have a high water table, but can be tile drained. They are medium to low in content of available nitrogen, very low to low in available phosphorus, and low in available potassium. Available iron is low in places. They contain excess lime and are wet because of the high water table.

Canisteo soils are suited to row crops if drained. Areas vary in size, but some areas are large. If drained, they are managed along with the adjacent Harps and Webster soils. In some places they are also managed along with the Nicollet and Clarion soils.

Representative profile of Canisteo silty clay loam, 320 feet north and 396 feet west of the southeast corner of NE¼ sec. 34, T. 81 N., R. 31 W., in an upland swale on a slope of about 1 percent:

Ap—0 to 9 inches, black (10YR 2/1) light silty clay loam, dark gray (10YR 4/1) when dry; cloddy breaking to weak, very fine, granular structure; friable; many sand grains; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

A1—9 to 18 inches, black (N 2/0) light silty clay loam, dark gray (10YR 4/1) when dry; moderate, fine and very fine, subangular blocky structure and moderate, fine, granular structure; friable; many sand grains; strongly effervescent; moderately alkaline; gradual, smooth boundary.

A3—18 to 24 inches, black (N 2/0) to very dark gray (N 3/0) light clay loam; weak, fine, subangular blocky structure and moderate, fine, granular structure; friable; strongly effervescent; moderately alkaline; gradual, smooth boundary.

B1g—24 to 28 inches, dark-gray (10YR 4/1) light clay loam; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, fine, prismatic structure breaking to weak, medium, subangular blocky; friable; thin, discontinuous, very dark gray (10YR 3/1) coatings on peds; strongly effervescent; moderately alkaline; clear, smooth boundary.

B2g—28 to 38 inches, light olive-gray (5Y 6/2) sandy clay loam; few, fine, prominent, strong-brown (7.5YR 5/6) mottles; weak, medium, prismatic structure breaking to weak, fine, subangular blocky; friable; few pebbles; strongly effervescent; moderately alkaline; gradual, smooth boundary.

Cg—38 to 60 inches, light olive-gray (5Y 6/2) to light-gray (5Y 6/1) loam to sandy clay loam; common, coarse, yellowish-brown (10YR 5/6) mottles; massive, some vertical cleavage; friable; few pebbles; strongly effervescent; mildly alkaline.

The surface layer is black to very dark gray silty clay loam 18 to 24 inches thick. It has enough sand to feel gritty. The subsoil is 12 to 18 inches thick and is dark gray, gray, or light olive gray. It ranges from clay loam or sandy clay loam to loam and contains some glacial pebbles or rocks. Yellowish-brown, dark yellowish-brown, strong-brown, or pale-olive mottles are in the subsoil. Carbonates are in all layers. The soil is mildly alkaline or moderately alkaline throughout.

Canisteo soils are similar to Webster soils, but they contain carbonates throughout. They have a thicker and darker surface layer, a lower content of free carbonates, and a lower content of clay in the upper part of the profile than Harps soils. They are darker colored in the surface layer when dry than Harps soils.

Canisteo silty clay loam (0 to 2 percent slopes) (507).—This soil is in irregularly shaped upland swales and low areas. It has a similar position on the landscape to Webster soils. The adjacent Nicollet, Clarion, and Harps soils are at slightly higher elevations. Okoboji soils are in depressions within areas of Canisteo soils. Individual areas range from about 10 to 40 acres in size.

Included with this soil in mapping are about 160 acres of a soil that has sand and gravel at a depth of 4 to 6 feet. These included soils are on benches and are associated with the Wadena and Cylinder soils. Also included are a few small areas of Okoboji and Harps soils. Harps soils 5 acres or less in size are shown on the map by the symbol for spots that have a high content of free lime.

This soil has a high water table and also receives some runoff water from adjacent soils at higher elevations. Much of the land is artificially drained and is cultivated. It is well suited to row crops if it is drained. (Capability unit IIw-1; woodland suitability group 9)

Clanton Series

The Clanton series consists of deep, moderately dark colored, moderately well drained soils on uplands. These soils are on the lower parts of side slopes. Clanton soils are only in valleys along the South Raccoon River and its major tributaries in Penn, Stuart, Beaver, and Jackson Townships. Slopes range from 18 to 30 percent.

These soils formed primarily in material weathered from acid red shale. The shale is about 6 to 20 feet thick. Layers of limestone and shale are below this depth. The native vegetation was mixed hardwoods and prairie grasses.

In a representative profile, the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is dark-gray and brown, friable silt loam about 4 inches thick. This layer is light gray when dry. The subsoil extends to a depth of about 40 inches. It is dark reddish-brown, dark reddish-gray, and weak-red silty clay and clay. A few brownish-yellow mottles occur, and they are more abundant in the lower part. The substratum is weak-red clay.

Clanton soils have a moderate available water capacity. They are very slowly permeable. These soils are extremely acid throughout. No water table occurs at a depth of less than 5 feet or at a depth of many feet. These soils are very low in content of available nitrogen, phosphorus, and potassium.

Clanton soils are suited to pasture and woodland. They are not suited to row crops. These soils absorb moisture very slowly, and runoff is rapid. These soils are easily eroded by runoff if vegetation is sparse.

Areas of Clanton soil are small. Because of their unfavorable chemical and physical properties, these soils limit the use of adjacent Gara and Lindley soils.

Representative profile of Clanton silt loam, 18 to 30 percent slopes, 20 feet north and 200 feet east of the southwest corner of NW1/4 sec. 22, T. 78 N., R. 30 W., on a west-facing convex side slope of about 20 percent:

A1—0 to 7 inches, very dark gray (10YR 3/1) heavy silt loam, gray (10YR 5/1) when dry; moderate, fine, granular structure; friable; very strongly acid; abrupt, smooth boundary.

A2—7 to 11 inches, dark-gray (10YR 4/1) and brown (7.5YR 4/2) silt loam, light gray (10YR 7/2) when dry; weak, very fine, subangular blocky structure; friable; thin, discontinuous, silty coatings on peds; common roots to a depth of 8 inches; extremely acid; clear, smooth boundary.

IIB1—11 to 14 inches, dark reddish-brown (2.5YR 3/4) and dark reddish-gray (5YR 4/2) light silty clay; weak, very fine, subangular blocky structure; firm; thin discontinuous silt coats; extremely acid; clear, smooth boundary.

IIB2—14 to 23 inches, weak-red (10R 4/3 to 2.5YR 4/2) clay; few, medium, distinct, brownish-yellow (10YR 6/8) mottles; weak, coarse, platy structure breaking to weak, very fine and fine, angular blocky; very firm; thin discontinuous clay films; very few black (N 2/0) fills in root channels; extremely acid; clear, smooth boundary.

IIB3—23 to 40 inches, weak-red (10R 4/3 to 2.5YR 4/2) clay; common, coarse, prominent, brownish-yellow (10YR 6/8) mottles; weak, coarse, platy structure; very firm; very few black (N 2/0) fills in root channels to a depth of 36 inches; extremely acid; diffuse, smooth boundary.

IIC—40 to 60 inches, weak-red (2.5YR 4/2) clay; common, coarse, prominent, brownish-yellow (10YR 6/8) mottles; platy structure; very firm; extremely acid.

The surface layer, 6 to 9 inches thick, is very dark gray to very dark grayish-brown silt loam unless eroded. The subsurface layer is dark grayish-brown to brown silt loam 2 to 6 inches thick. The subsoil is dark reddish-brown, dark reddish-gray, and weak-red clay or silty clay 10 to 36 inches or more thick. Brownish-yellow and yellowish-brown mottles occur. The substratum is weak-red, weathered silty clay or clay shale. These soils are strongly acid to extremely acid throughout.

Clanton soils have a slightly thicker surface layer and a redder subsoil than Gosport soils. They lack the stones and glacial pebbles in the subsoil that are in Adair and Armstrong soils. Clanton soils also have a clayey substratum and are more acid throughout than these soils. They have a thinner

surface layer than Clarinda soils and do not have a gleyed, gray subsoil.

Clanton silt loam, 18 to 30 percent slopes (318F).—This soil is on the lower part of convex upland side slopes. It is downslope from Gara and Lindley soils. In places, this soil is downslope from Clinton and Ladoga soils. Colo and Olmitz soils are generally below this soil on foot slopes and first bottom lands. Individual areas range from 3 to 10 acres in size.

Included with this soil in mapping are about 120 acres that have slopes of 14 to 18 percent, and a few areas of steeper soils. Also included are soils that have a less red subsoil and substratum.

Rainfall runoff is high because this soil is steep and the subsoil absorbs moisture very slowly. If vegetation is sparse, the surface layer quickly erodes and the infertile, clayey subsoil is exposed. This soil is suited to pasture and woodland. Some areas are so steep that farm machinery cannot be used safely to renovate pastures. (Capability unit VIIe-1; woodland suitability group 7)

Clarinda Series

The Clarinda series consists of deep, moderately dark colored, poorly drained soils on uplands. These soils are on short, convex side slopes or around the heads of drainageways. They are common in all but the northeastern part of the county. Individual areas range from 3 to 15 acres in size. Slopes range from 5 to 14 percent.

The Clarinda soils formed in parts of an old, gray, clayey soil that formed during an earlier geologic period. The old soil formed in clay loam glacial till and was later buried by loess. In time, the loess was removed by geologic erosion and new soils began to form. The remaining old, gray, clayey subsoil became the subsoil of the newly formed Clarinda soils. The clayey subsoil is about 3 to 10 feet thick in places. Below this layer is clay loam glacial till, 20 to more than 50 feet thick. The native vegetation was prairie grasses tolerant of excessive wetness.

In a representative profile, the surface layer is very dark gray silty clay loam about 11 inches thick. The upper 5 inches of the subsoil is grayish-brown silty clay loam. At a depth below 16 inches the subsoil is gray clay grading to light-gray clay at a depth of about 34 inches. Yellowish-red and strong-brown mottles are in this layer.

Clarinda soils have a high water capacity, but because of poor root development and the high clay content of the subsoil, not all of the water is available for plant use. These soils are very slowly permeable. They are slightly acid in the surface layer unless limed. Seepage water from soils upslope make this soil seasonally wet. When dry, the subsoil cracks and becomes extremely hard. At a depth of many feet the subsoil grades to a substratum of mottled, olive-gray and yellowish-brown, firm, clay loam glacial till. These soils are low in content of available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

The use of Clarinda soils is limited by wetness, hazard of erosion, low fertility, and poor tilth. Because of these hazards, Clarinda soils are managed as pasture in many places. Occasionally they are managed along with the adjacent soils and row cropped. The clayey subsoil is unfavorable for good root growth. Some areas of Clarinda soils are used for habitat for wildlife.

Representative profile of Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded, 500 feet south and 120 feet west of the northeast corner of SE¼NE¼ sec. 32, T. 78 N., R. 31 W., on a convex side slope of 7 percent:

Ap—0 to 7 inches, very dark gray (10YR 3/1) light silty clay loam, very dark grayish brown (10YR 3/2) where kneaded; weak, fine, subangular blocky structure and moderate, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A12—7 to 11 inches, very dark gray (10YR 3/1) and some dark grayish-brown (2.5Y 4/2) light to medium silty clay loam, very dark grayish brown (2.5Y 3/2) when kneaded; weak, fine, subangular blocky structure and weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

IIB1—11 to 16 inches, grayish-brown (2.5Y 5/2) medium silty clay loam, grayish brown (2.5Y 5/2) when kneaded; moderate, very fine and fine, subangular blocky structure; firm; some very dark gray (10YR 3/1) coatings on peds; medium acid; abrupt, smooth boundary.

IIB21tg—16 to 34 inches, gray (N 5/0) medium clay; many, coarse, prominent, yellowish-red (5YR 4/8) mottles between depths of 16 and 18 inches; moderate, medium, prismatic structure breaking to moderate, fine, subangular blocky; very firm; thick continuous clay films; slightly acid; gradual, smooth boundary.

IIB22tg—34 to 47 inches, light-gray (N 6/0) medium clay; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; massive; very firm; thick continuous clay films; few white sand grains; neutral; gradual, smooth boundary.

IIB3tg—47 to 60 inches, light-gray (N 6/0) medium clay; common, fine, strong-brown (7.5YR 5/6) and yellowish-red (5YR 4/6) mottles; some vertical cleavage; very firm; thick, continuous clay films on vertical faces; few white sand grains; neutral.

The surface layer is 10 to 16 inches thick. This layer is black or very dark gray. The subsoil is very firm, dark-gray, gray, or light-gray clay or silty clay. It is mottled with strong brown, yellowish brown, or yellowish red. The upper part of the subsoil is grayish brown in places. The clayey subsoil is very thick. Below the subsoil is mottled, olive-gray and yellowish-brown, firm, clay loam glacial till. These soils are medium acid to slightly acid in the most acid part of the surface layer and subsoil.

These soils have a thicker, grayer clayey subsoil than the Lamoni, Adair, or Armstrong soils. Clarinda soils have a distinct gray subsoil as compared to the brownish subsoil of Clanton and Gosport soils. They have a thicker surface layer than Armstrong, Clanton, or Gosport soils. Clarinda soils are higher in clay in the upper part of the subsoil than are Clearfield soils.

Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded (222C2).—This soil is on short side slopes and in heads of drainageways. It is generally downslope from Sharpsburg and Clearfield soils and upslope from Colo-Judson or Shelby-Adair soils. Individual areas are small. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few areas of Lamoni soils. In some places the surface layer is 6 to 10 inches thick.

This soil is seasonally wet because of seepage. A wet seepy band is above this soil near the boundary of the Sharpsburg or Clearfield soils upslope. Interceptor tile in the more permeable soils above reduces wetness. It dries out slowly after rains. During periods of low rainfall the

subsoil dries out extremely hard and cracks appear. The surface layer erodes when vegetation is sparse.

Some of this soil is cultivated. It is poorly suited to row crops even if erosion and wetness are controlled. If wetness is not controlled, this soil is generally in pasture. Most areas are managed along with the adjacent soils. (Capability unit IVw-1; woodland suitability group 7)

Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded (222D2).—This soil is on head slopes of drainageways and on side slopes. It is upslope from Shelby or Shelby-Adair soils and downslope from Sharpsburg soils. Individual areas are generally small.

Included with this soil in mapping are about 100 acres that are severely eroded and in which plowing has exposed the gray, clay subsoil. These areas are indicated on the map by spot symbols for severe erosion. Also included are small areas of Lamoni soils.

This soil is seasonally wet because of seepage. A wet seepy band is above this soil near the boundary of the Sharpsburg or Clearfield soils upslope. Interceptor tile placed in the more permeable soils above reduces wetness. This soil dries out slowly. The subsoil dries out extremely hard and cracks appear. If vegetation is sparse the surface layer erodes.

Most areas of this soil are in pasture. A few areas are managed along with the adjacent soil and are cultivated. This soil is poorly suited to row crops even if wetness and erosion are controlled. It is suitable for wildlife habitat. (Capability unit IVe-1; woodland suitability group 7)

Clarion Series

The Clarion series consists of deep, dark-colored, well-drained, loamy soils on uplands. Small rocks and pebbles are common in these soils. These soils are in the northeastern part of the county. They are on convex knolls and undulating ridgetops and side slopes. Individual areas range from 5 to many acres in size. Slopes range from 2 to 18 percent.

These soils formed in loam glacial till about 20 or more feet thick. On moderately steep soils that are adjacent to streams the till is thinner. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black and very dark brown loam about 11 inches thick. The subsoil is dark yellowish-brown to yellowish-brown, friable loam and sandy clay loam about 19 inches thick. The substratum, at a depth of about 30 inches, is yellowish-brown to light olive-brown, friable loam that is strongly effervescent. Some light-gray, strong-brown, and yellowish-red mottles are in the substratum.

The Clarion soils have high available water capacity. They are moderately permeable. The surface layer is neutral. The water table is at a depth of 5 feet or more. Clarion soils are low in content of available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Nearly all of the Clarion soils are cultivated. These sloping soils erode if vegetation is sparse.

A few areas of Clarion soils are large enough to be managed separately. Most areas are irregular in size and shape and are managed along with the adjacent Storden, Nicollet, and Webster soils.

Representative profile of Clarion loam, 2 to 5 percent slopes, 1,000 feet south and 66 feet east of the northwest corner of sec. 3, T. 81 N., R. 30 W., on a convex upland high of 3 percent:

Ap—0 to 7 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam; cloddy breaking to moderate, very fine, granular structure; friable; few pebbles; neutral; clear, smooth boundary.

A12—7 to 11 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) loam; moderate, fine, granular structure; friable; few dark yellowish coatings on peds in lower part; few pebbles; neutral; clear, smooth boundary.

B1—11 to 15 inches, dark yellowish-brown (10YR 4/4) loam; weak, fine, subangular blocky structure; friable; nearly continuous very dark grayish-brown (10YR 3/2) coatings on peds; few pebbles; slightly acid; clear, smooth boundary.

B2—15 to 21 inches, dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/6) sandy clay loam; weak, medium, subangular blocky structure; friable; nearly continuous brown (10YR 4/3) and few very dark grayish-brown (10YR 3/2) coatings on peds; few pebbles; neutral; gradual, smooth boundary.

B3—21 to 30 inches, yellowish-brown (10YR 5/4 to 5/6) loam; weak, coarse, prismatic structure breaking to weak, medium, subangular blocky; friable; common dark yellowish-brown (10YR 4/4) coatings on peds; few, fine, distinct, very dark brown (10YR 2/2) oxides; few pebbles; neutral; gradual, smooth boundary.

C—30 to 60 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) loam; few, fine, distinct, yellowish-red (5YR 5/6) mottles, few, medium, distinct, strong-brown (7.5YR 5/8) mottles, and few, coarse, distinct, light-gray (10YR 6/1) mottles; some vertical cleavage; friable; few to common fine black oxides; few pebbles; strongly effervescent; mildly alkaline.

The surface layer is black, very dark brown, or very dark grayish-brown loam that is 10 to 14 inches thick unless eroded. The subsoil is brown or dark yellowish brown to yellowish brown. It is 1 foot to 2½ feet thick. Mottles in the substratum range from gray to yellowish red, but gray is most common. The subsoil and substratum are generally loam, but thin layers of sandy clay loam occur in places. The surface layer and the upper part of the subsoil are neutral to slightly acid. Carbonates are at a depth between 24 and 36 inches in most places.

Clarion soils differ from Shelby soils in that they are friable, contain less clay, and generally have free carbonates at a shallower depth. They have a browner subsoil than Nicollet soils. Clarion soils have a thicker surface layer than Storden soils, and lack the free carbonates throughout. They have a thicker, dark surface layer, have less clay in the subsoil, and are less acid than Lester or Gara soils, and they lack a grayish subsurface layer. Clarion soils do not have a coarse-textured substratum, as do Wadena soils.

Clarion loam, 2 to 5 percent slopes (138B).—This soil is on convex upland knolls and occasionally on ridgetops. It is upslope from the adjacent Webster, Canisteo, Okoboji, and Nicollet soils. This soil has the profile described as representative for the series.

In some places the surface layer is about 12 to 14 inches thick. The surface layer is thicker at the base of slopes. In a few places the subsoil is thicker than normal, and calcareous loam glacial till is at a depth of 30 to 42 inches.

Nearly all of this soil is cultivated, and only a few areas are in pasture. It is well suited to row crops if erosion is controlled. Erosion control practices are some-

times difficult to establish because of the size and shape of areas. This soil is commonly managed along with the adjacent Nicollet soils and with the Webster and Okoboji soils if these soils are drained. (Capability unit IIe-2; woodland suitability group 3)

Clarion loam, 2 to 5 percent slopes, moderately eroded (138B2).—Most of this soil is on convex upland knolls. It is upslope from the adjacent Nicollet, Webster, Canisteo, and Okoboji soils. This soil has a profile similar to that described as representative for the series, but the surface layer is thinner and is very dark grayish brown. Plowing has exposed the brownish subsoil in some places.

Included with this soil in mapping are a few areas that have free carbonates throughout the profile and are similar to Storden soils. Also included are a few areas that have sandy loam about 2 feet thick over glacial till. The areas are indicated on the map by a spot symbol for sand.

Nearly all of this soil is cultivated. This soil is well suited to row crops if erosion is controlled. Erosion control practices are sometimes difficult to establish because of the size and shape of the areas. Nearly all of this soil is managed along with the adjacent Nicollet soils and with the Webster and Okoboji soils if these soils are drained. (Capability unit IIe-2; woodland suitability group 3)

Clarion loam, 5 to 9 percent slopes (138C).—This soil is on very undulating knolls and convex side slopes that border streams and upland drainageways. It is on similar landscapes to those occupied by Storden soils. This soil is upslope from Nicollet, Webster, and Okoboji soils. This soil has a profile like that described as representative for the series, but in some places the surface layer is thinner.

Included with this soil in mapping are a few areas of Storden soils. Some Nicollet soils are in the low parts of very undulating areas. Also included are a few soils at the base of steep slopes that have a thicker surface layer.

Most of this soil is cultivated, but some areas are in pasture. It is well suited or moderately well suited to row crops if erosion is controlled. This soil is commonly managed along with the adjacent, less sloping Clarion soils. In areas that are more strongly sloping, it is managed with steeper Clarion and Storden soils. (Capability unit IIIe-3; woodland suitability group 3)

Clarion loam, 5 to 9 percent slopes, moderately eroded (138C2).—Most of this soil is on convex side slopes that border streams and upland drainageways. In places it is on very undulating knolls. This soil is upslope from some Storden soils and from the Nicollet, Webster, and Okoboji soils. In other places it is below some Storden soils and the less sloping Clarion soils.

The surface layer is very dark grayish brown and is thinner than that described in the representative profile. Plowing has exposed the brownish subsoil in places. In places the depth to carbonates is 24 to 30 inches.

Included with this soil in mapping are some small areas of Storden soils.

Most of this soil is cultivated. It is moderately well suited to row crops if erosion is controlled. This soil is commonly managed along with less sloping Clarion soils. Areas that are more sloping are managed along with steeper Clarion and Storden soils and, in places, with the Lester soils. (Capability unit IIIe-3; woodland suitability group 3)

Clarion loam, 9 to 14 percent slopes, moderately eroded (138D2).—This soil is on convex side slopes that border stream valleys. It is downslope from the less sloping Clarion soils and is above bottom lands and stream benches. This soil has a profile similar to that described as representative for the series, except that the surface layer is thinner and very dark grayish brown. In places the subsoil is 8 to 18 inches thick. Calcareous loam till is at a depth of between 20 to 30 inches. Plowing has exposed the brownish subsoil in a few areas.

Included with this soil in mapping are some areas of Storden soils that are 2 to 5 acres in size. Also included are about 450 acres of a soil that has a very dark brown surface layer 10 to 14 inches thick.

Most of this soil is cultivated. Erosion is a hazard. This soil is moderately well suited to row crops if erosion is controlled. This soil is commonly managed along with the adjacent Storden soils and the less sloping Clarion soils. (Capability unit IIIe-4; woodland suitability group 3)

Clarion loam, 14 to 18 percent slopes (138E).—This soil is on convex side slopes adjacent to stream valleys. It is upslope from bottom lands and stream benches and is below the less sloping Clarion soils.

This soil has a profile like that described as representative for the series, except that the subsoil is generally 8 to 18 inches thick. Calcareous loam glacial till is at a depth between 20 and 30 inches. About half of the areas have a very dark grayish-brown surface or plow layer. The rest have a surface layer like that described in the representative profile, but it is generally a few inches thinner.

Included with this soil in mapping are areas of Storden soils that are 2 to 5 acres in size. Also included are severely eroded areas in which the brownish subsoil is exposed on the surface. These areas are indicated on the soil map by the symbol for severe erosion.

Most of this soil is in pasture. A few areas are used for row crops along with less sloping Clarion soils. Erosion is a hazard. This soil is poorly suited to row crops, even if erosion is controlled. (Capability unit IVe–2; woodland suitability group 3)

Clearfield Series

The Clearfield series consists of deep, dark-colored, poorly drained to somewhat poorly drained, silty soils on uplands. They are on short, convex side slopes and in coves on the upper part of head slopes. They are most common in the southeastern part of the county. Individual areas are generally less than 10 acres in size. Slopes range from 9 to 14 percent.

Clearfield soils formed in loess and parts of an old, clayey soil that formed during an earlier geologic period. The old, clayey soil is the lower part of the subsoil and the substratum of the Clearfield soils. The loess is about 3 feet thick, the old clay soil is about 10 feet thick, and below this is clay loam glacial till 20 to more than 50 feet thick. The native vegetation was prairie grasses that tolerate wetness.

In a representative profile, the surface layer is very dark brown silty clay loam about 15 inches thick. The upper part of the subsoil, to a depth of 35 inches, is very dark grayish-brown and olive-gray, friable medium silty clay loam mottled with yellowish brown and strong brown. The lower part of the subsoil and the substratum are dark-gray and gray, very firm silty clay.

Clearfield soils have a high available water capacity. They are moderately slowly permeable in the upper 3 feet but very slowly permeable in the clayey lower part of the subsoil and in the substratum. The surface layer is generally slightly acid to medium acid unless limed. These soils are wet and seepy during parts of the year. Drainage water from the more permeable soils upslope moves laterally over the very slowly permeable clayey lower part of the subsoil and the substratum and makes this soil seasonally wet. These soils are low to medium in available nitrogen, very low to low in available phosphorus, and medium in available potassium.

Clearfield soils are erodible if vegetation is sparse. They puddle easily if worked wet. If artificially drained they are managed along with the adjacent Sharpsburg soils and cultivated. Some areas are managed as pasture along with the associated Clarinda soils downslope.

Representative profile of Clearfield silty clay loam, 9 to 14 percent slopes, moderately eroded, 115 feet south and 100 feet west of the northeast corner of NW¼ sec. 31, T. 78 N., R. 31 W., on a northwest-facing head slope of 7 percent:

Ap—0 to 7 inches, very dark brown (10YR 2/2) light silty clay loam, dark grayish brown (10YR 4/2) when dry; cloddy breaking to weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

A1—7 to 15 inches, very dark brown (10YR 2/2) light silty clay loam, dark gray (10YR 4/1) to dark grayish brown (10YR 4/2) when dry; weak, medium, subangular blocky structure breaking to moderate, medium, granular; friable; neutral; gradual, smooth boundary.

B1t—15 to 20 inches, very dark grayish-brown (2.5Y 3/2) medium silty clay loam, dark grayish brown (2.5Y 4/2) when kneaded; moderate, fine, subangular blocky structure; friable; thin discontinuous clay films; slightly acid; gradual, smooth boundary.

B21t—20 to 26 inches, dark grayish-brown (2.5Y 4/2) to grayish-brown (2.5Y 5/2) medium silty clay loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine, prismatic structure breaking to moderate, fine, subangular blocky; friable; thin discontinuous clay films; slightly acid; clear, smooth boundary.

B22tg—26 to 35 inches, olive-gray (5Y 5/2) medium to heavy silty clay loam; common, coarse, faint, olive-gray (5Y 4/2) mottles on vertical faces; common, medium, distinct, strong-brown (7.5YR 5/8) mottles; weak, medium, prismatic structure breaking to moderate, fine, subangular blocky; friable; thin discontinuous clay films; common, soft, strong-brown oxides; neutral; clear, smooth boundary.

IIB3g—35 to 44 inches, dark-gray (5Y 4/1) light silty clay; common, medium, distinct, olive-brown (2.5Y 4/4) mottles; weak, coarse, subangular blocky structure; very firm; common, soft, strong-brown oxides; common pores; few roots; neutral; clear, smooth boundary.

IICg—44 to 48 inches, gray (5Y 5/1) light silty clay; few, fine, distinct, olive-brown (2.5Y 4/4) mottles; massive; very firm; common, fine, black oxides; few pores; neutral.

The surface layer is 10 to 16 inches thick unless eroded. It is very dark brown, very dark gray, or black. The subsoil is 20 to 30 inches thick. The upper part of the subsoil is very dark gray or very dark grayish brown in most places. Mottles of gray, olive gray, olive brown, strong brown, and yellowish brown are in the subsoil. At a depth of 3 to 5 feet, the lower part of the subsoil and the substratum are dark-gray, olive-gray, or gray, very firm silty clay. The silty clay is about 10 feet thick in most places. These soils are medium acid to slightly acid in the surface layer and upper part of the subsoil. The lower part of the subsoil and the substratum are slightly acid or neutral in reaction.

Clearfield soils have a grayer subsoil than the Sharpsburg and Macksburg soils, and they are underlain by silty clay. They are less clayey in the upper part of the subsoil than Clarinda soils. Clearfield soils contain less sand in the subsoil than the Lamoni soils.

Clearfield silty clay loam, 9 to 14 percent slopes, moderately eroded (69D2).—This soil is on the upper part of head slopes and on short side slopes above Clarinda and Lamoni soils. It is downslope from Sharpsburg and Macksburg soils. Individual areas are not large.

Included with this soil in mapping are about 170 acres of soil that have a slope of 5 to 9 percent. Also included are some places where the surface layer is thinner. In a few areas the subsoil is mixed with the very dark grayish-brown plow layer.

This soil is in a wet, seepy band on head slopes and side slopes. Interceptor tile placed above the clayey substratum reduces wetness. The surface layer erodes if vegetation is sparse.

Some of this soil is tile drained and managed along with the adjacent Sharpsburg soils. Field operations are delayed in cultivated areas that are not artificially drained. This soil is poorly suited to row crops, even if erosion and wetness are controlled. Some areas are left in pasture and managed with the Clarinda or Lamoni soils downslope. (Capability unit IVe-1; woodland suitability group 9)

Clinton Series

The Clinton series consists of deep, light-colored, moderately well drained, silty soils on uplands. These soils are on narrow, convex ridgetops and side slopes. A few areas are on high stream benches. These soils are most common in the strongly dissected areas near streams and their tributaries in the southeastern part of the county. Individual areas range from 5 to about 20 acres in size. Slopes range from 2 to 14 percent.

Clinton soils formed in loess that is 10 to 16 feet thick in most places, but only 4 feet thick on some side slopes. The loess is underlain by an old, reddish or grayish, clayey soil 2 to 10 feet thick. Beneath this buried soil is clay loam glacial till 20 to more than 50 feet thick. On high stream benches, the loess is underlain by an old alluvial soil of red and gray clay or by stratified loamy alluvium. The native vegetation was trees.

In a representative profile, the surface layer is very dark gray silt loam about 4 inches thick. The subsurface layer is grayish-brown to dark grayish-brown, friable silt loam about 5 inches thick. This layer is distinctly light colored when dry. The subsoil extends to a depth of about 52 inches. It is dark yellowish-brown and yellowish-brown, firm silty clay loam mottled with light brownish gray in the lower part. The substratum is mottled

yellowish-brown and light brownish-gray, friable light silty clay loam.

The Clinton soils have high available water capacity. Permeability is moderately slow. The surface layer is medium acid to strongly acid unless limed. These soils are low in content of available nitrogen, low to medium in available phosphorus, and medium in available potassium.

The less sloping Clinton soils are mostly cleared of trees and are cultivated. Other areas are wooded or partly wooded and are used for pasture. These soils are easily eroded by runoff if vegetation is sparse.

Many areas of Clinton soils are large enough to be managed as individual fields. Most of the more sloping areas are managed as pasture along with the Gara and Lindley soils downslope. Areas that have a good tree cover can be managed as woodland.

Representative profile of Clinton silt loam, 9 to 14 percent slopes, moderately eroded, 150 feet north and 200 feet west of the southeast corner of SW¼ sec. 15, T. 79 N., R. 30 W., on a convex side slope of 9 percent:

Ap—0 to 4 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak, thick, platy structure breaking to moderate, fine, granular; friable; slightly acid; abrupt, smooth boundary.

A2—4 to 9 inches, grayish-brown (10YR 5/2) to dark grayish-brown (10YR 4/2) silt loam, very pale brown (10YR 7/3) when dry; moderate, medium, platy structure; friable; strongly acid; abrupt, smooth boundary.

B1—9 to 14 inches, yellowish-brown (10YR 5/4) light silty clay loam; weak, medium, subangular blocky structure breaking to moderate, very fine, angular and subangular blocky; friable; abundant pale-brown silt coatings; very strongly acid; clear, smooth boundary.

B21t—14 to 21 inches, dark yellowish-brown (10YR 4/4) heavy silty clay loam; strong, very fine, angular and subangular blocky structure; firm; thick, discontinuous clay films; few pale-brown silt coatings; very strongly acid; gradual, smooth boundary.

B22t—21 to 28 inches, dark yellowish-brown (10YR 4/4) medium to heavy silty clay loam; strong, fine and very fine, angular and subangular blocky structure; firm; thick, discontinuous clay films; very strongly acid; gradual, smooth boundary.

B31t—28 to 41 inches, yellowish-brown (10YR 5/4) medium silty clay loam; moderate, medium and fine, angular and subangular blocky structure; firm; thick, discontinuous clay films; strongly acid; gradual, smooth boundary.

B32t—41 to 52 inches, yellowish-brown (10YR 5/4 to 5/6) light silty clay loam; very few, fine, light brownish-gray (2.5Y 6/2) mottles; very weak, medium and coarse, subangular and angular blocky structure; friable; very few, discontinuous clay films; medium acid; gradual, smooth boundary.

C—52 to 60 inches, mottled yellowish-brown (10YR 5/4) and light brownish-gray (2.5Y 6/2) light silty clay loam; massive; friable; medium acid.

The surface layer is 2 to 5 inches thick unless eroded. It is very dark gray, very dark brown, or very dark grayish-brown, friable silt loam. In cultivated areas, it is generally dark grayish brown. The subsurface layer is grayish-brown to dark grayish-brown and brown, friable silt loam 4 to 8 inches thick. The subsoil is brown, yellowish-brown, and dark yellowish-brown, firm silty clay loam to light silty clay 2 to 4 feet thick. Mottles of light brownish gray, grayish brown, strong brown, and yellowish brown are in the lower part of the subsoil and in the substratum. The substratum is mottled, yellowish-brown, light brownish-gray, or grayish-brown, friable, light silty clay loam. These soils are strongly acid to very strongly acid in the upper part of the subsoil and medium acid to slightly acid in the substratum.

The Clinton soils have a thinner dark-colored surface layer than the Ladoga soils. They are silty and lack the reddish color and the stones and pebbles that are in the Lindley soils. Clinton soils have a thinner dark surface layer than Armstrong soils and lack the reddish colors and the stones and pebbles in the subsoil.

Clinton silt loam, 2 to 5 percent slopes (80B).—This soil is on narrow, convex ridgetops above the more sloping Clinton soils. In places it is associated with soils of the Ladoga series on similar slopes. Individual areas are generally 5 to 10 acres in size.

This soil has a profile similar to the one described as representative for the series, except that the subsurface layer is 2 to 4 inches thicker. The plow layer is dark grayish brown. In a few places where the subsurface layer is lacking, the plow layer is immediately underlain by the brownish subsoil. In places the lower part of the subsoil and the substratum are dominantly light brownish gray or grayish brown at a depth below about 36 inches.

The surface layer is low in organic-matter content, but this soil is easily tilled. If vegetation is sparse, this soil is easily eroded by runoff.

This soil is well suited to row crops if erosion is controlled. Most areas of this soil are cultivated, but a few areas are in pasture or woodland. Small areas of this soil are generally managed along with the more sloping Clinton soils on side slopes. (Capability unit IIe-1; woodland suitability group 2)

Clinton silt loam, 5 to 9 percent slopes, moderately eroded (80C2).—This soil is on narrow, elongated, convex ridgetops and side slopes. In most places it is upslope from the more sloping Clinton soils and downslope from the less sloping Clinton and Ladoga soils. A few areas are above soils of the Gara or Lindley series or Gara-Armstrong loams. Individual areas are generally less than 20 acres in size.

In cultivated areas, plowing has mixed the surface and subsurface layers. The plow layer is dark grayish brown and, in many places, is immediately underlain by the brownish subsoil.

Included with this soil in mapping are small areas where the brownish subsoil is exposed. These places are indicated on the soil map by the symbol for severely eroded spots.

The surface layer is thin and low in organic-matter content. It is easily eroded by runoff if vegetation is sparse.

This soil is well suited or moderately well suited to row crops if erosion is controlled. Most of this soil has been cleared and is cultivated. A few small areas upslope from the steep Lindley soils are used for pasture or woodland. This soil is generally managed with the less sloping Clinton and Ladoga soils on ridgetops. (Capability unit IIIe-1; woodland suitability group 2)

Clinton silt loam, 9 to 14 percent slopes, moderately eroded (80D2).—This soil is on convex side slopes below the less sloping Clinton soils on ridgetops. It is upslope from Lindley soil and, in places, from Gara-Armstrong loams. Individual areas are generally 5 to 20 acres in size.

This soil has the profile described as representative for the series. In cultivated areas, plowing has mixed the subsurface and surface layers. The plow layer is dark grayish brown and is immediately underlain by the brownish subsoil. In small areas of this soil that are

severely eroded, the brownish subsoil is exposed. These areas are indicated on the soil map by a symbol for severely eroded spots.

This soil has a thin surface layer that is low in organic-matter content. In places it is cloddy and has poor tilth. The surface layer is easily eroded if vegetation is sparse.

Almost all of this soil has been cleared and was once cultivated. Some areas that were formerly cultivated are now used for pasture. Trees and brush are encroaching on a few such areas along drainageways. Areas not used for trees are only fairly well suited to row crops, even if erosion is controlled. Small areas of this soil are generally managed along with the associated Lindley soils on side slopes. (Capability unit IIIe-2; woodland suitability group 2)

Clinton soils, 9 to 14 percent slopes, severely eroded (80D3).—These soils are on the upper part of convex side slopes below the less sloping Clinton and Ladoga soils. They are above Lindley and Gara soils and Gara-Armstrong loams. The areas are 5 to 20 acres in size.

These soils have a slightly thinner subsoil than that described in the profile representative for the series. The surface layer is dark-brown or brown silt loam or silty clay loam. Tilth is poor. These soils are subject to erosion if vegetation is sparse.

These soils are better suited to pasture than to row crops. Sidehill drainageways develop into gullies unless runoff is controlled. Trees and brush encroach on pastures along drainageways. Small areas provide excellent habitat for wildlife. Most of the acreage is managed along with the Ladoga and Clinton soils upslope. (Capability unit IVe-2; woodland suitability group 2)

Colo Series

The Colo series consists of deep, dark-colored, poorly drained, silty soils on low foot slopes, first bottom lands, and alluvial fans. The largest areas are along major streams and their tributaries. These soils also occur as a complex with other soils in narrow upland drainageways. Individual areas range from 5 to 40 acres in size. Slopes range from 0 to 5 percent.

Colo soils formed in silty alluvium that is 4 to 20 feet or more thick. Below this is stratified loamy or sandy alluvium many feet thick. The native vegetation was grasses and sedges that tolerate excessive wetness.

In a representative profile, the surface layer is black to very dark gray light silty clay loam about 39 inches thick. Below this, the substratum is mottled, very dark gray, firm medium silty clay loam.

Colo soils have a high available water capacity. They are moderately slowly permeable. They have a high water table unless artificially drained. The surface layer is generally neutral to slightly acid, but in some places it is more acid and need lime. These soils are medium to low in content of available nitrogen, low to very low in available phosphorus, and medium in available potassium. Colo soils are wet and flood in places. All Colo soils are suited to cultivation if wetness and flooding are controlled.

Areas of Colo soils are generally large in size and can be managed as individual fields. Small areas are managed along with the associated Judson, Ely, Nodaway, and Zook soils. Colo soils are the most extensive bottom-land soil in the county.

Representative profile of Colo silty clay loam, 0 to 2 percent slopes, 310 feet south and 450 feet west of the northeast corner of SW¼ sec. 35, T. 80 N., R. 32 W., on first bottom land of 1 percent slope:

Ap—0 to 8 inches, black (10YR 2/1) light silty clay loam; cloddy breaking to weak, very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

A12—8 to 15 inches, black (10YR 2/1 to N 2/0) light silty clay loam; moderate, medium, granular structure and very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A13—15 to 24 inches, black (10YR 2/1) to very dark gray (10YR 3/1) light silty clay loam; weak, fine, subangular blocky structure; friable; few, faint, grainy coatings on peds, gray (10YR 5/1) when dry; neutral; gradual, smooth boundary.

A14—24 to 39 inches, black (10YR 2/1) to very dark gray (10YR 3/1) medium silty clay loam; weak, medium, prismatic structure breaking to weak, fine, subangular blocky; firm; neutral; gradual, smooth boundary.

C1g—39 to 50 inches, very dark gray (10YR 3/1) medium silty clay loam; few, fine, distinct, dark-brown (10YR 3/3) mottles; massive; firm; neutral; gradual, smooth boundary.

C2g—50 to 59 inches, very dark gray (10YR 3/1) medium silty clay loam; common, fine, distinct, dark-brown (10YR 3/3) mottles; massive; firm; neutral; gradual, smooth boundary.

C3g—59 to 68 inches, very dark gray (10YR 3/1) medium silty clay loam; common, fine, faint, dark grayish-brown (10YR 4/2) mottles; massive; firm; neutral.

The surface layer is black or very dark gray and is 36 to 40 inches thick. It is friable silt loam or light silty clay loam in the upper part and friable and firm light to medium silty clay loam in the lower part. The average clay content between depths of 10 to 40 inches is less than 35 percent. The subsoil and substratum are very dark gray, dark gray, or gray, firm medium silty clay loam. Mottles of brown, olive brown, or yellowish brown are in the subsoil and substratum. These soils are neutral to slightly acid in the surface layer. The substratum is generally neutral but ranges to slightly acid.

These soils are not so high in content of clay as Zook soils. They are more poorly drained and have less clay in their profile than Kennebec soils. Colo soils have a thicker dark surface layer than Humeston and Vesser soils and lack the grayish subsurface layer that these soils have. They also are less clayey in the lower part of the profile than the Humeston soils.

Colo silty clay loam, 0 to 2 percent slopes (133A).—This soil is on bottom lands of major streams and their tributaries. It is downslope from Judson, Ely, and Nevin soils. It is common in all parts of the county.

This soil has the profile described as representative for the series. In places, however, it has up to 8 inches of brownish-colored overwash on the surface. In some areas, it has stronger structural development than that described as representative for the series.

Unless drained and protected from flooding, this soil is wet. Areas that have received recent overwash are lower in available nitrogen than is representative for the series.

Much of this soil is artificially drained and cultivated. A few areas are protected from flooding. It is well suited to row crops if wetness is controlled. Many areas are managed as individual fields. In some places this soil is managed along with Nodaway, Zook, Vesser, and Humeston soils. (Capability unit IIw-2; woodland suitability group 9)

Colo silty clay loam, 2 to 5 percent slopes (133B).—This soil is on alluvial fans or low foot slopes that grade to bottom lands. It is upslope from Colo and Zook soils on bottom lands and downslope from upland soils derived from loess and glacial till. This soil occurs throughout the county. In the northeastern part of the county, it commonly is in upland drainageways.

The surface layer is generally black silty clay loam, but in places it is dark-gray or very dark grayish-brown gritty silt loam in the upper 10 inches. At a depth of about 3 feet and below, the subsoil and substratum are generally grayer than described as representative for the series. Included with this soil in mapping in the northeastern part of the county are some loamy soils of the Spillville series.

This soil receives runoff and some sediments from the surrounding uplands. Much of the acreage is artificially drained and cultivated. A few small areas associated with steep upland soils are in pasture. This soil is well suited to row crops if it is drained or protected from flooding. Because many areas are small in size, this soil is generally managed along with the surrounding soils. (Capability unit IIw-3; woodland suitability group 9)

Colo silt loam, channeled, 0 to 2 percent slopes (C133A).—This soil is along small streams and in wide upland drainageways. It is dissected by noncrossable, meandering stream channels and drainageways. In places, it is downslope from Ely and Judson soils, and it is commonly next to Nodaway soils and other Colo soils.

The profile of this soil differs from the profile described as representative for the series in that the surface layer is very dark grayish-brown silt loam or gritty silt loam about 18 inches thick. Below this is a buried soil similar to the Colo series.

After heavy rains runoff water spills from the meandering channels onto this soil and deposits unfertile sediments. Flash flooding occurs, and new channels are cut and old ones are partly filled.

Nearly all of this soil is in pasture or is partly wooded. Only a small acreage is cultivated along with the associated bottom land soils. If this soil is used for pasture, control of flooding and of young tree growth are needed. Some areas are excellent for wildlife habitat. (Capability unit Vw-1; woodland suitability group 9)

Colo silt loam, overwash, 0 to 2 percent slopes (133A+).—This soil is on bottom lands of small streams and in wide upland drainageways. It is also on nearly level fans at the mouth of upland drainageways. Individual areas are irregular in shape and range from 5 to 20 acres in size.

This soil has a profile similar to the one described as representative for the series, but the surface layer is very dark grayish-brown silt loam. This layer is recent alluvium deposited by flooding. It is 8 to 18 inches thick and has a lower nitrogen content than in the representative profile. Below this is the buried Colo soil. Included with this soil in mapping are about 800 acres of a soil that has a surface layer of black, friable silt loam.

This soil is flooded during periods of heavy rainfall. Wetness caused by a high water table and flooding limits its use. Some of this soil is artificially drained. Many areas need protection from flooding. This soil is well suited to row crops if wetness and flooding are controlled. Small areas in upland drainageways are commonly managed as pasture. A small, noncrossable drainageway is generally in these places. (Capability unit IIw-2; woodland suitability group 9)

Colo silt loam, overwash, 2 to 5 percent slopes (133B+).—This soil is on low alluvial fans at the mouths of upland drainageways. It is above Colo soils on bottom lands and downslope from Shelby and Gara soils. Individual areas are generally less than 10 acres in size.

The surface layer is very dark grayish-brown, friable silt loam 8 to 18 inches thick. It is lower in nitrogen than is representative for the series. In some places the surface layer is black. This layer is recent alluvium deposited by flooding. Below this deposit is a soil similar to that described as representative for the series. Included with this soil in mapping are a few areas that have a silty clay subsoil and substratum.

The soil receives runoff and sediments from surrounding uplands. Wetness caused by a high water table is generally not so serious a limitation as runoff and sedimentation. This soil is well suited to row crops if wetness and runoff are controlled. Because most areas are small in size, this soil is generally managed along with the associated soils. Areas adjacent to steep uplands are managed as pasture. (Capability unit IIw-3; woodland suitability group 9)

Colo-Judson complex, 2 to 5 percent slopes (11B).—This soil complex is along narrow, upland drainageways in nearly all but the northeastern parts of the county. In most areas there is one crossable or noncrossable drainageway. Individual areas are in narrow, elongated strips bordered by steep soils on uplands.

This complex consists of more than 60 percent Colo soils and the remainder is Judson soils. Both Colo and Judson soils have profiles similar to those described as representative for their respective series. The Colo soils are in the most nearly level part of the area near the watercourse. Judson soils are near the base of slopes.

Included with these soils in mapping are some areas of Ely soils. The acreage of these Ely soils increases in the southwestern part of the county. In many places the surface layer is about 8 to 15 inches of very dark grayish-brown silt loam or gritty silt loam recent sediment. Near the base of upland slopes the surface layer is generally very dark brown silty clay loam.

Runoff from surrounding uplands drains onto this complex. In some places gullies form and need to be shaped and stabilized. Farm ponds are commonly built in these soils.

Part of this complex is cultivated. This complex is suited to row crops if runoff from the surrounding uplands is controlled, wetness is reduced by drainage, and waterways are developed. In some places growth of young trees and shrubs needs to be controlled. (Capability unit IIw-3; woodland suitability group 9)

Colo-Spillville complex, 2 to 5 percent slopes (585B).—This soil complex is around drainageways and at the base of upland slopes. A crossable drainageway is generally in these areas. In the northeastern part of the county these soils are downslope from Clarion, Storden, and Lester soils. In the southern or southeastern part of the county they are downslope from Shelby, Montieth,

Gara, or Lindley soils. Areas are narrow and are 5 to 20 acres in size.

Colo soils make up about 60 to 70 percent of the complex. They are near the drainageway. Spillville soils, near the base of upland slopes, make up 30 to 40 percent of the complex. The Colo and Spillville soils in this complex have profiles similar to the ones described as representative for their respective series. In places, Olmitz soils, rather than Spillville soils, occur. The texture of the surface layer ranges from loam to silty clay loam in places.

This complex receives runoff from soils upslope. The surface layer dries out slowly after rains. Recent sediments of low fertility are deposited on the surface layer in places.

This complex is well suited to row crops if artificially drained and protected from runoff. Most areas are managed along with adjacent soils on uplands. In the southern or southeastern part of the county some areas are left idle or used as pasture. These places are also well suited for wildlife habitat. Young trees and shrubs grow well in these areas. (Capability unit IIw-3; woodland suitability group 9)

Colo-Spillville complex, channeled, 2 to 5 percent slopes (615B).—This soil complex is in upland drainageways in the northeastern part of the county. Several noncrossable stream channels or drainageways are in these areas. It is downslope from upland till soils, such as Clarion, Storden, and Lester soils. Areas are long and narrow and range from 5 to 20 acres in size.

Colo soils make up about 60 percent of the complex, and loamy Spillville soils, the remaining 40 percent. Spillville soils occur as a band near the base of slopes. The Colo and Spillville soils in this complex have profiles similar to the ones described as representative for their respective series. Colo soils in this part of the county contain slightly more sand than is representative for the series. The surface layer ranges from loam or silt loam to silty clay loam in places.

Runoff from surrounding upland soils drains onto this complex. After heavy rains, water overflows the meandering channels and flooding occurs. Recent low-fertility sediments are deposited, new channels are formed, and old channels are partly filled.

Nearly all of this complex is used for pasture. Some areas are excellent for wildlife habitat. Some areas are suited to cultivation if stream channel improvements are made and flooding and wetness are controlled. If these soils are used for pasture, flooding and growth of young trees and shrubs need to be controlled. (Capability unit Vw-1; woodland suitability group 9)

Cylinder Series

The Cylinder series consists of dark-colored, somewhat poorly drained, loamy soils that are moderately deep to deep over sandy or gravelly materials. These soils are on benches along stream valleys in and bordering the northeastern part of the county. Individual areas are generally 5 to 20 acres in size. Slopes are less than 2 percent.

Cylinder soils formed in about 2 to 3 feet of loamy alluvium over sandy or gravelly alluvium. The coarser textured alluvium ranges from 4 feet to many feet in thickness. In places it is underlain by glacial till or sediments from glacial till. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black loam about 16 inches thick. The subsoil is very dark grayish-brown loam to a depth of about 22 inches. Below this it is mottled, grayish-brown and light olive-brown loam grading to sandy loam to loam that contains some gravel. The substratum, at a depth of about 38 inches, is grayish-brown to light brownish-gray, loose gravelly loamy sand.

The Cylinder soils generally have moderate available water capacity. They are moderately permeable in the loamy material and rapidly permeable below. The water table is at a depth of about 2 to 4 feet, and the underlying sandy or gravelly material is saturated part of the year. These periods of saturation are brief during the growing season. In places these soils receive runoff from soils upslope. The surface layer is generally neutral to slightly acid, but in places it is more acid and needs additions of lime. Cylinder soils are low to medium in content of available nitrogen and available potassium and low in available phosphorus.

All the acreage is cultivated. Because individual areas are small, they are generally managed along with the Spillville and Wadena soils upslope or downslope. Other areas are managed along with Webster soils and, in a few areas, with Salida soils.

Representative profile of Cylinder loam, 300 feet west and 150 feet north of the southeast corner of SW¼ sec. 27, T. 81 N., R. 30 W., on a slope of 1 percent:

Ap—0 to 9 inches, black (10YR 2/1) loam; weak, fine, granular structure; friable; neutral; clear, smooth boundary.

A12—9 to 16 inches, black (10YR 2/1) heavy loam; some very dark grayish-brown (2.5Y 3/2) peds similar to material in B1 horizon; weak, fine, granular structure; friable; neutral; gradual, smooth boundary.

B1—16 to 22 inches, very dark grayish-brown (2.5Y 3/2) heavy loam; weak, fine, subangular blocky structure; friable; common black (10YR 2/1) organic coatings on peds; neutral; gradual, smooth boundary.

B2—22 to 32 inches, mottled grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; very dark gray (10YR 3/1) organic coatings on peds; few roots; common tubular pores; neutral to mildly alkaline; gradual, smooth boundary.

B3—32 to 38 inches, grayish-brown (2.5Y 5/2) sandy loam to loam that has some gravel; common, medium, distinct, light olive-brown (2.5Y 5/4) mottles; weak, medium, subangular blocky structure; very friable; very few roots; few tubular pores; strongly effervescent; mildly alkaline; gradual, smooth boundary.

IIC—38 to 66 inches, grayish-brown (2.5Y 5/2) to light brownish-gray (2.5Y 6/2) gravelly loamy sand; single grain; loose; strongly effervescent; moderately alkaline.

The surface layer is black or very dark gray, friable loam 14 to 20 inches thick. The upper part of the subsoil is mottled dark grayish-brown, grayish-brown, olive-brown, or light olive-brown, friable loam. The lower part is sandy clay loam or sandy loam to loam that has some gravel. The substratum is similar to the subsoil in color, but in places it is also light brownish gray or olive gray. The depth to the underlying sand, gravel, or gravelly loamy sand ranges from 24 to 40 inches, but in most places it is more than 30 inches. The subsoil is neutral or mildly alkaline. Carbonates are in the underlying sandy material.

The Cylinder soils are grayer and more mottled in the subsoil than the better drained Wadena soils. Cylinder soils are loamy and are underlain by sandy materials, but Nevin and

Ely soils are silty to a depth of more than 4 feet. Cylinder soils are not so well drained as the Salida soils. They have a grayer, more mottled subsoil than the Salida soils and are not so shallow to sandy or gravelly material and carbonates.

Cylinder loam (0 to 2 percent slopes) (203).—This soil is on stream benches of valleys in the northeastern part of the county. It is associated with Wadena, Salida, and, in places, Spillville and Webster soils. The individual areas are about 10 acres in size.

Most of this soil consists of 30 to 40 inches of loamy material underlain by sandy material. In a few places the loamy material is only about 24 inches in thickness.

Included with this soil in mapping are some areas where the loamy material ranges to 48 inches in thickness. Also included are a few areas that are slightly more acid and that lack free lime at a depth of less than 4 feet.

This somewhat poorly drained soil is generally not droughty. Occasionally, water from soils upslope drains across this soil.

This soil is well suited to row crops. Nearly all of it is cultivated. Because individual areas are small, they are mostly managed along with associated soils on benches. In a few places this soil is managed with soils on uplands or first bottoms. (Capability unit I-2; woodland suitability group 6)

Dickinson Series

The Dickinson series consists of deep, dark-colored, well-drained to somewhat excessively drained, loamy soils on uplands. They are on convex side slopes and ridgetops. Most of these soils are in river and stream valleys in all but the northeastern part of the county. These soils occur only as a complex with the loess-derived Sharpsburg soils. Slopes range from 5 to 14 percent.

Dickinson soils formed in fine sandy loam and loamy sand eolian materials that are, in most places, 4 to 10 feet thick. Several feet of loess is below this depth. The loess is underlain by glacial till. The glacial till is as much as 50 feet thick in places. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown fine sandy loam about 14 inches thick. The subsoil is brown, very friable fine sandy loam about 16 inches thick. Below this, the substratum is yellowish-brown, loose loamy fine sand.

These soils have low available water capacity. They are moderately rapidly permeable in the loamy material and rapidly permeable in the sandy material. The water table is at a depth below 6 feet or more. The surface layer is generally neutral to slightly acid, but some areas are more acid and need additions of lime. They are low in available nitrogen and phosphorus and medium in available potassium. Dickinson soils are droughty in years that have below average rainfall. They warm up rapidly in spring and can be worked soon after rains. These soils erode rapidly if the surface layer is bare or vegetation is sparse.

Most of these soils are cultivated because they are associated with the loess-derived soils. They are suited to cultivation if erosion is controlled.

Representative profile of Dickinson fine sandy loam, in an area of Dickinson-Sharpsburg complex, 9 to 14 percent slopes, moderately eroded, 66 feet north and 610 feet west of the southeast corner of SW¼SE¼ sec. 5, T. 81 N., R. 33 W., on an east-facing slope of 9 percent:

A1—0 to 11 inches, very dark brown (10YR 2/2) fine sandy loam; weak, medium, subangular blocky structure breaking to weak, medium, granular; very friable; neutral; gradual, smooth boundary.

A3—11 to 14 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, medium, subangular blocky structure breaking to weak, medium, granular; very friable; slightly acid; gradual, smooth boundary.

B2—14 to 22 inches, brown (10YR 4/3) fine sandy loam; weak, medium, subangular blocky structure; very friable; common roots; slightly acid; gradual, smooth boundary.

B3—22 to 30 inches, brown (10YR 5/3) fine sandy loam; weak, medium, subangular blocky structure; very friable; few roots; slightly acid; diffuse, smooth boundary.

C—30 to 60 inches, yellowish-brown (10YR 5/4) loamy fine sand; single grain; loose; neutral.

The surface layer is very dark brown, very dark gray, or very dark grayish-brown, very friable fine sandy loam 10 to 20 inches thick. A few areas have a loam texture. The subsoil is brown, dark yellowish-brown, or yellowish-brown, very friable fine sandy loam 10 to 20 inches thick. The lower part of the subsoil is loamy fine sand in places. The substratum is yellowish-brown, loose loamy sand, but in a few places it is very friable sandy loam. These soils are typically slightly acid in the subsoil but range to medium acid and are slightly acid to neutral in the substratum.

Dickinson soils are not so shallow to carbonates as Salida soils and lack the gravel that Salida soils have. They contain more sand and have less clay in the subsoil than the Marshall, Sharpsburg, and Ladoga soils. Dickinson soils are not so acid as the Montieth and Hesch soils. They lack the reddish and strong-brown bands that occur in Montieth soils, and they have fine sand in the subsoil rather than medium as in Hesch soils. Montieth and Hesch soils formed in material weathered from sandstone.

Dickinson-Sharpsburg complex, 5 to 9 percent slopes, moderately eroded (675C2).—This soil complex is on convex ridgetops and upper side slopes both upslope and downslope from Sharpsburg, Marshall, and Ladoga soils. Individual areas generally range from 5 to 20 acres in size.

Dickinson soils make up about 60 percent of the complex, and Sharpsburg soils make up most of the remaining 40 percent. The Dickinson and Sharpsburg soils have profiles similar to the ones described as representative for their respective series. Included with this complex in mapping in the western part of the county are Marshall soils. Also included are a few areas of Ladoga soils. Some of the Sharpsburg soils have silty and sandy lenses in the substratum.

This complex erodes if vegetation is sparse. The Dickinson part of the complex is droughty during seasons of low rainfall. Crops are stunted and irregular in size. Soil blowing is also a hazard if the surface layer is bare.

Nearly all of this complex is cultivated. This complex is well suited or moderately well suited to row crops if erosion is controlled. It is generally managed with the associated loess-derived soils. (Capability unit IIIe-3; woodland suitability group 1)

Dickinson-Sharpsburg complex, 9 to 14 percent slopes, moderately eroded (675D2).—This soil complex is on convex upper side slopes both upslope and downslope from Sharpsburg, Marshall, and Ladoga soils. Individual areas range from 10 to 40 acres in size.

Dickinson soils make up about 50 percent of the complex and Sharpsburg soils make up most of the remaining 50 percent. The Dickinson soil has the profile described as representative for the series. The Sharpsburg soil has a profile similar to that described as representative for the series. In the western part of the county, Marshall soils, rather than Sharpsburg soils, make up a large part of the complex. Ladoga soils, rather than Sharpsburg soils, are in the complex in a few areas in the southern part of the county. Some Sharpsburg soils have silty and sandy lenses in the substratum.

The Dickinson part of the complex is droughty during seasons of low rainfall. Crops are stunted and irregular in size. This complex erodes if vegetation is sparse. Both soil blowing and erosion are hazards.

Much of this complex is cultivated. This complex is moderately well suited to row crops if erosion is controlled. Most areas are managed with the associated loess-derived soils on side slopes. (Capability unit IIIe-4; woodland suitability group 1)

Ely Series

The Ely series consists of deep, dark-colored, somewhat poorly drained, silty soils on uplands. They are on concave low foot slopes and fans. They are upslope from Colo, Zook, and Nevin soils and downslope from Sharpsburg soils and occasionally from Shelby soils. Individual areas are 5 to 10 acres in size. Slopes range from 2 to 5 percent.

Ely soils formed in silty alluvium 4 to more than 10 feet thick. Below that depth is clay loam till or loess or, in some places, buried alluvial soils. The native vegetation was prairie grasses.

In a representative profile, the surface layer is light to medium silty clay loam about 24 inches thick. It is very dark brown to very dark gray in the upper part, black in the middle, and black to very dark gray in the lower part. The subsoil is mottled, dark grayish-brown, very dark gray to very dark grayish-brown, and olive-brown, friable, medium silty clay loam about 23 inches thick. The substratum is olive-brown, friable light silty clay loam mottled with some grayish brown and dark brown.

These soils have high available water capacity. They are moderately permeable. They have a temporary water table at a depth of 2 to 6 feet in places during parts of the year. They are slightly acid to medium acid in the surface layer unless limed. Ely soils are medium to low in available nitrogen, low in available phosphorus, and medium in available potassium. Runoff from soils upslope rills these soils in places. In some areas, recent sediments of low fertility are deposited on the surface layer.

Most of these soils are cultivated. They are suited to cultivation if runoff and sedimentation are controlled. Because individual areas are small, Ely soils are generally managed with the associated Colo, Zook, or Nevin soils downslope.

Representative profile of Ely silty clay loam, 2 to 5 percent slopes, 100 feet east and 70 feet south of the northwest corner of NE¼ sec. 29, T. 80 N., R. 31 W., on a foot slope of 3 percent:

Ap—0 to 7 inches, very dark brown (10YR 2/2) to very dark gray (10YR 3/1) light silty clay loam; cloddy breaking to weak, very fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A12—7 to 16 inches, black (10YR 2/1) light silty clay loam; moderate, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

A13—16 to 24 inches, black (10YR 2/1) to very dark gray (10YR 3/1) medium silty clay loam; weak, fine, subangular blocky structure and moderate, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

B1—24 to 34 inches, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) medium silty clay loam, very dark grayish brown (10YR 3/2) when kneaded; weak to moderate, fine and very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B2—34 to 42 inches, dark grayish-brown (2.5Y 4/2) and olive-brown (2.5Y 4/4) medium silty clay loam; weak, medium, prismatic structure breaking to moderate, fine, subangular blocky; friable; slightly acid; gradual, smooth boundary.

B3—42 to 47 inches, dark grayish-brown (2.5Y 4/2) and olive-brown (2.5Y 4/4) medium silty clay loam; weak, medium, prismatic structure breaking to weak, medium, subangular blocky; friable; few, fine, black oxides; few, thin, discontinuous silt coats on peds; slightly acid; gradual, smooth boundary.

C—47 to 60 inches; olive-brown (2.5Y 4/4) light silty clay loam; common, fine, grayish-brown (2.5Y 5/2) mottles and few, fine, dark-brown (10YR 4/3) mottles; very weak, medium, prismatic structure; friable; slightly acid.

The surface layer is black, very dark brown, and very dark grayish-brown light to medium silty clay loam ranging from 24 to 30 inches in thickness. The lower part of the subsoil is dark grayish brown, grayish brown, and olive brown to light olive brown. The subsoil is 20 to 30 inches thick and extends to a depth of about 60 inches or more in places. The substratum is generally mottled, light olive-brown, yellowish-brown, and grayish-brown, light to medium silty clay loam. Ely soils are slightly acid to medium acid in the surface layer and upper part of the subsoil but slightly acid or neutral in the lower part of the subsoil and in the substratum.

These soils are more poorly drained than Judson soils and have a grayer, mottled subsoil. They have a thicker surface layer and a less developed subsoil than Macksburg and Nevin soils. Ely soils also have less clay in the subsoil than Macksburg soils. They are not so poorly drained as the Colo soils and have a browner subsoil.

Ely silty clay loam, 2 to 5 percent slopes (428B).—This soil is on low, concave foot slopes and fans. It is downslope from Sharpsburg soils and occasionally downslope from Shelby soils, but it is upslope from Colo, Zook, and Nevin soils.

Included with this soil in mapping are a few areas that have a browner, less mottled subsoil. Also included are about 150 acres of soils that have a surface layer of very dark grayish-brown silt loam 8 to 18 inches thick.

Wetness does not limit the use of this soil, but field operations are delayed in some years. The surface layer does not dry out so readily as in some of the associated soils on uplands. Water from soils upslope drains across this soil. Rill erosion is common.

This soil is cultivated. It is well suited to row crops if runoff and siltation are controlled. Most of the soil is in small areas, and it is managed along with the Nevin, Colo, or Zook soils downslope. (Capability unit IIe-3; woodland suitability group 6)

Gara Series

The Gara series consists of deep, moderately dark colored, moderately well drained, loamy soils on uplands. They are on irregular, convex side slopes. Gara soils are downslope from Ladoga and Armstrong soils and upslope from Olmitz soils and from soils on bottom lands and stream benches. They are most common in stream valleys in the southern and central parts of the county. Individual areas range from 10 to 40 acres in size. Slopes range from 9 to 40 percent.

Gara soils formed in clay loam glacial till that is 20 to more than 50 feet thick in places. Below this is generally a buried, clayey soil and many more feet of glacial till. Native vegetation was trees and prairie grasses.

In a representative profile, the surface layer is very dark gray loam about 6 inches thick. The subsurface layer is dark grayish-brown, friable loam about 3 inches thick. The subsoil is dark yellowish-brown and yellowish-brown, medium to heavy clay loam about 21 inches thick. The subsoil is friable in the upper 3 inches but is firm at a depth below 12 inches. Some grayish mottles are in the lower part of the subsoil. The substratum is mottled brown and yellowish-brown, firm clay loam. The mottles are light gray or grayish brown and increase in size and abundance as depth increases. A few stones and pebbles are commonly in the profile.

Gara soils have high available water capacity. They are moderately slowly permeable. If a water table occurs, it is at a depth of 6 feet or more. These soils are medium acid or slightly acid in the surface layer unless limed. Gara soils are low to very low in available nitrogen, very low to low in phosphorus, and low to medium in available potassium. These soils erode if vegetation is sparse. Many areas are dissected by side-hill gullies and drainageways. Some are noncrossable. In eroded spots, tilth is poor, and tillage is difficult.

The less sloping Gara soils are cultivated and the steeper soils are managed as pasture. Some areas are in scattered woods, and grazing is limited. Many areas are large enough to be managed as individual fields. Closely associated soils, such as Armstrong soils in a complex with Gara soils and soils of the Colo-Judson complex, are generally managed along with Gara soils.

Representative profile of Gara loam, 18 to 25 percent slopes, moderately eroded, 107 feet south and 700 feet west of the northeast corner of sec. 24, T. 79 N., R. 32 W., on a convex side slope of 20 percent:

A1—0 to 6 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; moderate, very fine, subangular blocky structure breaking to moderate, fine, granular; friable; continuous black (10YR 2/1) coatings on peds; slightly acid; clear, smooth boundary.

A2—6 to 9 inches, dark grayish-brown (10YR 4/2) to very dark grayish-brown (10YR 3/2) heavy loam, dark grayish brown (10YR 4/2) when kneaded, light grayish brown (10YR 6/2) when dry; moderate, medium, subangular blocky structure; friable; some very dark gray (10YR 3/1) coatings on peds; few pebbles; medium acid; clear, smooth boundary.

B1—9 to 12 inches, dark yellowish-brown (10YR 4/4) medium clay loam, brown (10YR 5/3) when dry; moderate, medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; friable; nearly continuous brown (10YR 4/3) coatings on peds and some very dark gray (10YR 3/1) coatings on peds; some pebbles; medium acid; gradual, smooth boundary.

B21t—12 to 17 inches, yellowish-brown (10YR 5/4) medium to heavy clay loam; moderate, fine, subangular blocky structure breaking to moderate, very fine, subangular and angular blocky; firm; thin, nearly continuous, brown (10YR 4/3) clay films; few dark grayish-brown silt coatings on peds; few tubular pores; some pebbles; medium acid; diffuse, smooth boundary.

B22t—17 to 26 inches, yellowish-brown (10YR 5/4) medium to heavy clay loam; weak, medium, subangular blocky structure breaking to moderate and strong, very fine, subangular blocky; firm; thin, continuous, brown (10YR 4/3) to dark yellowish-brown (10YR 4/4) clay films; some very dark gray (10YR 3/1) colors in roots and worm channels; few tubular pores; some pebbles; slightly acid; gradual, smooth boundary.

B3t—26 to 30 inches, yellowish-brown (10YR 5/4) medium clay loam; common, medium, distinct, light-gray (10YR 6/1) mottles; weak, medium, prismatic structure breaking to moderate, fine, subangular blocky; firm; thin, nearly continuous brown (10YR 4/3 to 5/3) clay films; few oxide concretions; some pebbles; neutral; gradual, smooth boundary.

C1—30 to 43 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) medium to light clay loam; few, medium, distinct, brown (7.5YR 4/4) mottles and few, fine to medium, distinct, light-gray (10YR 6/1) mottles; some vertical cleavage; firm; common, large, lime concretions; few brown (10YR 4/3 to 5/3) ped coatings; some pebbles; strongly effervescent; mildly alkaline; clear, smooth boundary.

C2—43 to 60 inches, yellowish-brown (10YR 5/4) medium to light clay loam; common, medium, distinct, light-gray (10YR 6/1) mottles and few, medium, grayish-brown (2.5Y 5/2) mottles; massive; firm; abundant, coarse, lime concretions; strongly effervescent; mildly alkaline.

The surface layer is very dark gray or very dark grayish-brown, friable loam about 6 to 10 inches thick. The subsurface layer is brown or light grayish-brown when dry and is 0 to 6 inches thick. Cultivated areas or eroded areas commonly have both layers mixed in the plow layer. In these places the plow layer is immediately underlain by the browner subsoil. The subsoil is brown, dark yellowish-brown, and yellowish-brown, firm medium clay loam. Thin layers of heavy clay loam are in the subsoil. The substratum is brown and yellowish-brown, firm medium clay loam. Mottles of gray and grayish brown are in the lower part of the subsoil and increase in size and abundance as depth increases. Gara soils are medium acid to very strongly acid in the most acid part of the subsoil. Carbonate concretions generally are at depths between 24 and 42 inches.

Gara soils are lower in clay than Armstrong soil and lack the reddish hues in the subsoil. They have a thicker or darker colored surface layer and a less distinct subsurface layer than Lindley soils. Gara soils have a thinner surface layer than Shelby soils, and they have a grayish subsurface layer.

Gara loam, 9 to 14 percent slopes, moderately eroded (179D2).—This soil is on convex side slopes that are generally smooth and are only occasionally dissected by side-hill drainageways. This soil is downslope from Ladoga soils and upslope from Olmitz-Colo complex or, in places, Colo-Judson soils in drainageways. This soil is in bands on the hillsides in areas 10 to 20 acres in size.

In cultivated areas the surface layer is very dark grayish brown loam. The subsoil is thicker than in the profile described as representative for the series, and carbonates are below a depth of 40 inches in many places.

Included with this soil in mapping are a few small areas that have reddish, clayey subsoil. Also included

are a few areas that have a thinner, less dark surface layer.

This sloping soil erodes if vegetation is sparse. In places gullies form. Part of this soil is cultivated, and the remaining areas are in pasture or woods and pasture. This soil is poorly suited to row crops, even if erosion is controlled. Gullies need to be reshaped and seeded in places. Young trees and shrubs often encroach along side-hill drainageways and need to be removed before this soil is cultivated. In places this soil is managed along with Colo-Judson soils. (Capability unit IVe-1; woodland suitability group 3)

Gara loam, 14 to 18 percent slopes, moderately eroded (179E2).—This soil commonly occupies entire convex side slopes. Both crossable and noncrossable side-hill drainageways dissect this soil. It is generally downslope from Ladoga soils and generally upslope from Olmitz-Colo complex or, in places, from Colo-Judson soils. It is most common in the central and southeastern parts of the county. Individual areas range from 10 to 40 acres or more in size.

This soil has a profile similar to the one described as representative for the series. In most places, however, carbonates are below a depth of 36 inches. A few areas have been cultivated in the past and have a surface layer of very dark grayish-brown, friable loam immediately underlain by the brownish subsoil.

Included with this soil in mapping are a few small areas that have a reddish, clayey subsoil. Also included are about 140 acres of Lester soils that have less clay in the subsoil and substratum than this soil.

Nearly all of this soil is in pasture. The remaining part is in woods or woods and pasture. Only a few small areas are cultivated along with adjacent less sloping soils. Erosion is a hazard in areas that have been cleared and where vegetation is sparse. Gullies are common. This soil is better suited to pasture than to crops. Young trees and shrubs encroach on pasture unless controlled. Areas are large and can be managed as individual fields. (Capability unit VIe-2; woodland suitability group 3)

Gara loam, 18 to 25 percent slopes, moderately eroded (179F2).—This soil is on long, convex side slopes of stream valleys. Crossable and noncrossable side-hill drainageways and gullies are common. This soil is downslope from Ladoga soils or, in places, from Gara-Armstrong soils and it is generally upslope from Olmitz-Colo complex or bottom-land soils. Areas occupy entire side slopes and are 10 to 40 acres or larger in size. This is the major Gara soil in the county.

Most of this soil has a surface layer of very dark grayish-brown loam about 7 inches thick. This is underlain by a brownish subsoil. Areas that are wooded have the profile described as representative for the series.

Included with this soil in mapping on the upper parts of slopes are some soils that have a reddish, clayey subsoil. Also included are about 125 acres of Lester soils that are similar but have less clay in the subsoil and substratum than Gara soils.

Runoff is rapid on this steep soil, and it erodes if the surface layer is bare. Side-hill drainageways develop into gullies in places. Farm tillage equipment can be used for pasture renovation, but gullies and drainageways are hazardous to cross in many places.

This soil is better suited to pasture than to crops. A few areas have good stands of trees and can be managed as woodland. Most areas are large enough to be managed as individual fields. Some areas are managed along with Colo-Judson soils downslope. Stock ponds and erosion control structures are built in this soil. (Capability unit VIIe-1; woodland suitability group 4 or 5)

Gara loam, 25 to 40 percent slopes, moderately eroded (179G2).—This soil is on irregular, convex side slopes dissected by crossable and noncrossable side-hill drainageways and gullies. It is downslope from less sloping Gara and Ladoga soils or, in places, from Gara-Armstrong soils, and it is upslope from Olmitz-Colo soils and soils on bottom lands. Individual areas are 5 to 20 acres in size. This soil has a profile similar to the one described as representative for the series, but in cleared areas the surface layer is generally very dark grayish brown.

Included with this soil in mapping are a few severely eroded spots where the brownish subsoil is at the surface. Carbonates are at a depth as shallow as 24 inches in places.

Most of this soil has some tree cover. Much of it is managed as pasture. A few areas can be managed as woodland. Runoff is rapid, and this soil erodes if it is cleared and vegetation is sparse. Gullies are common. Farm tillage equipment cannot be operated safely on most of this soil.

Cleared or partly wooded areas are suited to pasture. Some areas managed as woodland are also well suited to wildlife habitat. Stock ponds and erosion control structures are built in this soil. (Capability unit VIIe-1; woodland suitability group 4 or 5)

Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded (993E2).—This complex is on irregular, convex side slopes. In places it is high on the side slopes above steeper Gara soils. In other areas it is on short side slopes below Ladoga soils. Individual areas range from 5 to 15 acres in size.

The Gara and Armstrong soils have profiles similar to those described as representative of their respective series. Gara soils make up about 50 to 75 percent of the complex, and Armstrong soils make up the remaining 25 to 50 percent. The Armstrong soils are on the upper part of side slopes adjacent to the Ladoga soils. Included with these soils in mapping are a few areas that have a gray, clayey subsoil.

Runoff water erodes these soils if vegetation is sparse. The Armstrong soil in the complex erodes more readily, and it is seepy and wet in periods of high rainfall. The Armstrong soil is difficult to till if eroded. Most areas of these soils are dissected by side-hill drainageways. In a few places there are noncrossable gullies.

These soils are suited to pasture. A few small areas are cultivated with the associated Gara or Ladoga soils. Gullies should be shaped and reseeded. Young trees and shrubs grow along drainageways unless controlled. A few areas have good tree cover and can be managed as woodland. Some areas are large and can be managed as individual fields. (Capability unit VIe-1; woodland suitability group 3)

Gosport Series

The Gosport series consists of deep, moderately dark colored, moderately well drained, silty soils on uplands. They are on short, convex, low parts of side slopes that border the South Raccoon River in Penn, Stuart, Beaver, and Jackson Townships. They are downslope from Ladoga, Clinton, Gara, Lindley, and Montieth soils. Individual areas are generally small but range from 5 to 20 acres in size. Slopes range from 9 to 30 percent.

Gosport soils formed in silty clay loam or silty clay shale that is many feet thick. Color of the shale is variable but is generally gray and brown. Native vegetation was trees or trees and prairie grasses.

In a representative profile, the surface layer is very dark gray silt loam about 9 inches thick. The subsurface layer is dark grayish-brown, friable silt loam about 4 inches thick. The subsoil is about 33 inches thick. It is mottled, light olive-brown, grayish-brown, and light olive-gray heavy silty clay loam in the upper part and light olive-gray to pale-olive heavy silty clay loam to silty clay in the lower part. The substratum is pale-olive and light olive-gray heavy silty clay loam to silty clay shale mottled with strong brown.

Gosport soils have moderate available water capacity. They are very slowly permeable. They are medium acid or strongly acid in the surface layer unless limed. They are very low in available nitrogen, phosphorus, and potassium.

These soils erode if vegetation is sparse. In addition they resist saturation and absorb water slowly. Because of high runoff and limited absorption they tend to be droughty. Root growth is limited by moisture and fertility. In eroded spots tilth is poor and tillage is difficult.

Few areas of these soils are used for cultivation; most are in pasture or woods and pasture. They are generally managed along with the associated soils upslope.

Representative profile of Gosport silt loam, 9 to 18 percent slopes, moderately eroded, 770 feet south and 130 feet east of the southwest corner of lot 14, sec. 4, T. 78 N., R. 31 W., or 4,470 feet south and 1,450 feet east of the northwest corner of the section, on a convex slope of 18 percent:

A1—0 to 9 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; weak, medium, platy structure breaking to moderate, fine and very fine, granular; friable; medium acid; gradual, smooth boundary.

A2—9 to 13 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) when dry; weak, medium, platy structure; friable; strongly acid; abrupt, smooth boundary.

B1—13 to 15 inches, light olive-brown (2.5Y 5/4) silty clay loam, light brownish gray (2.5Y 6/2) when dry; faces of peds dark grayish brown (2.5Y 4/2) to grayish brown (2.5Y 5/2); moderate, fine, subangular blocky structure; friable; few, fine, dark oxides; strongly acid; gradual, smooth boundary.

B2—15 to 34 inches, light olive-brown (2.5Y 5/4), grayish-brown (2.5Y 5/2), and light olive-gray (5Y 6/2) heavy silty clay loam; few, medium, brown (7.5YR 4/4) and strong-brown (7.5YR 5/6) mottles; weak, coarse, subangular and angular blocky structure; firm; few, fine, dark oxides; strongly acid; gradual, smooth boundary.

B3—34 to 46 inches, light olive-gray (5Y 6/2) and pale-olive (5Y 6/3) heavy silty clay loam to silty clay; very weak, coarse, angular blocky structure that has evidence of horizontal cleavage; firm, strongly acid; gradual, smooth boundary.

C—46 to 60 inches, pale-olive (5Y 6/3) and light olive-gray (5Y 6/2) heavy silty clay loam to silty clay shale; common, strong-brown (7.5YR 5/6) mottles; massive, some horizontal cleavage; firm; few dark-gray (10YR 4/1) seams or streaks; medium acid grading to slightly acid at a depth of 54 inches.

The surface layer is very dark gray or very dark grayish-brown, friable silt loam 3 to 9 inches thick. The subsurface layer is dark grayish-brown or grayish-brown, friable silt loam 3 to 7 inches thick. The subsoil is light olive-brown, light olive-gray, pale-olive, and grayish-brown heavy silty clay loam or silty clay. The substratum is similar to the subsoil in color and texture. Mottles of yellowish brown, dark brown, and strong brown are in the substratum. Gosport soils are strongly acid to extremely acid in the most acid part of the subsoil.

Gosport soils differ from the Clinton, Ladoga, Gara, or Lindley soils in that they formed in shale, have a less developed subsoil, are more acid, and have a higher clay content in the substratum. They also lack the stones and pebbles present in Gara and Lindley soils.

Gosport silt loam, 9 to 18 percent slopes, moderately eroded (313E2).—This soil is on the lower part of convex side slopes. It is downslope from Gara, Lindley, and, in places, Montieth soils and upslope from bottom-land soils, such as Colo or Zook soils. In places this soil is within areas of Lindley soils. Individual areas are commonly less than 10 acres in size. This soil has the profile described as representative for the series, although the surface layer is thinner in places.

Included with this soil in mapping are a few soils that have a reddish or yellowish-brown subsoil.

Most areas of this soil are wooded or partly wooded and used for pasture. This soil erodes if cleared of trees or if vegetation is sparse. This soil is strongly sloping to moderately steep, but farm tillage equipment can be used to renovate pastures. Stock ponds are generally not built in or near this soil because of the cracking and shifting of the shale subsoil and the occurrence of sandstone above areas of this soil.

This soil is suited to pasture. Young trees and shrubs encroach on pasture unless controlled. Most areas are small in size and managed along with the associated Lindley or Gara soils. (Capability unit VIIe-1; woodland suitability group 7)

Gosport silt loam, 18 to 30 percent slopes, moderately eroded (313F2).—This soil is on the lower part of convex side slopes. It is downslope from Gara, Lindley, and, in places, Montieth soils. It is upslope from soils on bottom lands. Individual areas are 5 to 20 acres in size. This soil has a profile similar to the one described as representative for the series, except that the subsoil is thinner. Unaltered shale is at a depth of about 24 to 30 inches.

Included with this soil in mapping are a few soils that have a reddish or yellowish-brown subsoil.

Areas of this soil are mostly wooded or partly wooded and used for pasture. A few areas are managed as woodland. Runoff is rapid, and this soil erodes if it is cleared and vegetation is sparse. Some areas are gullied. Farm tillage equipment cannot be operated safely on some of the steeper parts of this soil.

Cleared or partly wooded areas are suited to pasture. Stock ponds are generally not built in or near this soil

because of the cracking and shifting of the shale subsoil and the occurrence of sandstone above areas of this soil. Young trees and shrubs encroach on pasture unless controlled. A few areas are suited to habitat for wildlife. Most of this soil is managed with the associated Lindley, Gara, or Montieth soils. (Capability unit VIIe-1; woodland suitability group 7)

Harps Series

The Harps series consists of deep, moderately dark colored or dark colored, poorly drained, loamy soils on uplands. The surface layer and subsoil have a high content of lime. These soils are on narrow convex rims around Okoboji soils in depressions or potholes. Harps soils are also on slight rises within areas of Webster and Canisteo soils on broad upland flats. Individual areas are narrow and small in size. Slopes are less than 2 percent.

Harps soils formed in glacial till and sediments derived from glacial till. Native vegetation was grasses tolerant of excessive wetness.

In a representative profile, the surface layer is very dark gray heavy loam about 16 inches thick. It generally contains snail shells or fragments of shells and is very high in content of calcium carbonate. It is distinctly gray when dry. The subsoil, to a depth of about 29 inches, is dark-gray, gray, and olive-gray, friable loam. The substratum is olive-gray and olive loam mottled with olive and strong brown. Both the subsoil and substratum are high in content of calcium carbonate but less so than the surface layer.

Harps soils have high available water capacity. They are moderately permeable. They have a high water table and are saturated during parts of the year unless drained. They are moderately alkaline in the surface layer and have abundant amounts of lime. These soils are low in available nitrogen and very low in available phosphorus and potassium. They are wet. If the surface layer is left bare by plowing, soil blowing is a hazard.

Most of these soils are drained and cultivated. All of the areas are too small to be managed as individual fields. Fertility is so low that many areas need special treatment. Harps soils are managed along with the Okoboji, Webster, and Canisteo soils.

Representative profile of Harps loam, 126 feet north and 870 feet east of the southwest corner of SE¼ sec. 14, T. 81 N., R. 30 W., on a convex rim of a depressional 1 percent slope:

Apca—0 to 8 inches, very dark gray (N 3/0) heavy loam, gray (10YR 5/1) when dry; cloddy breaking to weak, coarse, granular structure; friable; common snail shell fragments; violently effervescent; moderately alkaline; clear, smooth boundary.

A12ca—8 to 16 inches, very dark gray (N 3/0) and gray (N 4/0) heavy loam, very dark gray (N 3/0) when kneaded, gray (10YR 5/1) when dry; weak, medium, subangular blocky structure breaking to moderate, fine, granular; friable; common shell fragments or lime concretions; violently effervescent; moderately alkaline; gradual, smooth boundary.

B1gca—16 to 22 inches, dark-gray (5Y 4/1) loam; weak, medium, subangular blocky structure; friable; common shell fragments or lime concretions; violently effervescent; moderately alkaline; gradual, smooth boundary.

B2gca—22 to 29 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) loam; weak, medium, subangular blocky structure; friable; common small lime concretions; violently effervescent; moderately alkaline; gradual, smooth boundary.

C1g—29 to 39 inches, olive-gray (5Y 5/2) loam; common, medium, distinct, olive (5Y 5/6) mottles; massive; friable; common small lime concretions; strongly effervescent; moderately alkaline; gradual, smooth boundary.

C2g—39 to 60 inches, olive (5Y 5/3) loam; common, medium, prominent, strong-brown (7.5YR 5/6) mottles; massive; friable; common lime concretions; strongly effervescent; moderately alkaline.

The surface layer is generally very dark gray or black loam or light clay loam about 10 to 18 inches thick. It is distinctly gray when dry. The subsoil is 10 to 20 inches thick and is dark gray, gray, and olive-gray, friable loam or light clay loam that is 18 to 30 percent clay. The subsoil generally has slightly less clay than the surface layer. The substratum is olive, olive-gray, or light olive-brown, friable loam that is 18 to 24 percent clay. A few glacial pebbles are in all layers. The substratum has mottles similar to those in the lower part of the subsoil. Free lime is in all layers. The surface layer and the subsoil are higher in content of calcium carbonate than the substratum.

Harps soils are higher in content of calcium carbonate than Canisteo and Webster soils and usually have less clay in the surface layer and upper part of the subsoil. They are also higher in calcium carbonate and lower in clay than Okoboji soils and are not dark colored to as great a depth.

Harps loam (0 to 2 percent slopes) (95).—This soil is on narrow convex rims that border the Okoboji soils. It is also on slight rises that form an irregular soil pattern within large areas of Canisteo or Webster soils. Individual areas are generally about 5 acres in size.

Small areas of this soil are indicated on the soil map by the symbol for spots that have a high content of free lime. Because this soil is very high in lime and very unfertile, small areas influence the management of associated soils.

The soil is wet unless tiled and requires additions of fertilizer if used for row crops. It is well suited to row crops if these hazards are controlled.

Most of this soil is presently tiled and managed along with associated soils. Some areas need additional tile or better tile outlets. (Capability unit IIw-1; woodland suitability group 9)

Hesch Series

The Hesch series consists of deep, dark-colored, well-drained to somewhat excessively drained, loamy soils on uplands. These soils occur as bands on the lower parts of side slopes. They are in the valleys of the Middle Raccoon and South Raccoon Rivers, Brushy Creek, and their tributaries. Individual areas range from about 5 to 40 acres in size. Slopes range from 9 to 18 percent.

Hesch soils formed in material weathered from sandstone. The surface layer formed in material weathered from sandstone or from loamy sediments derived from glacial till. Below the sandstone is clayey shale or limestone bedrock several feet thick. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown sandy loam about 12 inches thick. The subsoil is brown and dark yellowish-brown, friable, heavy sandy loam in the upper

part and dark yellowish-brown and strong-brown, loose to friable, medium loamy sand in the lower part. At a depth of about 46 inches and below, the substratum is yellowish-brown, loose, medium sand.

Hesch soils have low available water capacity. They are moderately rapidly permeable. The surface layer is strongly acid unless limed. In some places the surface layer is loam and contains a few pebbles or small rocks. They are very low in available nitrogen, available phosphorus, and available potassium.

Erosion and soil blowing, low fertility, and droughtiness are hazards that limit the use of Hesch soils. Most areas are in pasture, but small areas of the less sloping soils are cultivated.

Some areas of Hesch soil are large and can be managed as separate fields. Most areas are managed with Montieth soils downslope or Shelby and Gara soils upslope.

Representative profile of Hesch sandy loam, 9 to 18 percent slopes, 510 feet north and 100 feet west of the southeast corner of NE¼ sec. 23, T. 80 N., R. 32 W., on a north-facing, convex side slope of 11 percent:

A1—0 to 6 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; very friable; strongly acid; clear, smooth boundary.

A3—6 to 12 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, fine, granular structure; very friable; some brown (10YR 4/3) peds; strongly acid; clear, smooth boundary.

B1t—12 to 18 inches, brown (10YR 4/3) heavy sandy loam; weak, medium, subangular blocky structure; friable; some very dark grayish brown (10YR 3/2) in worm channels and on ped faces; common clay bridging; medium acid; gradual, smooth boundary.

B2t—18 to 24 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, medium to coarse, subangular blocky structure; friable; common clay bridging; medium acid; clear, smooth boundary.

B31—24 to 29 inches, dark yellowish-brown (10YR 4/4) medium loamy sand; very weak, fine, subangular blocky structure; loose; some pebbles; medium acid; clear, smooth boundary.

B32t—29 to 46 inches, strong-brown (7.5YR 5/8) medium loamy sand; single grain; friable; common clay bridging; sand grains not clean; medium acid; gradual, smooth boundary.

C—46 to 60 inches, yellowish-brown (10YR 5/6) medium sand; single grain; loose; less evidence of clay bridging; sand grains not clean; medium acid.

The surface layer is very dark brown, very dark gray, or very dark grayish-brown, friable loam or sandy loam 10 to 16 inches thick unless eroded. A surface layer that has a loam texture generally contains a few glacial stones and pebbles. The subsoil is brown, dark yellowish brown, strong brown, and yellowish brown. The upper 10 to 18 inches is heavy sandy loam. The lower part consists of bands that are loamy medium sand or sand in places. The substratum is at depths between 36 and 48 inches. It is yellowish-brown, grayish-brown, brown, or very pale brown, loose medium sand. Slightly to moderately cemented sandstone is at depths between 40 and 60 inches in most places. Most of the sand is medium in size. Hesch soils are medium acid to strongly acid in the subsoil and substratum.

The Hesch soils in this county contain less clay in the subsoil than the defined range for the series. This difference does not alter their usefulness and behavior.

Hesch soils have a thicker sandy loam subsoil than Montieth soils and a thicker dark surface layer. They are more acid than Dickinson soils and the sand in the profile of the Hesch soils is medium in size rather than fine.

Hesch sandy loam, 9 to 18 percent slopes (416E).—This soil is on the lower part of convex side slopes. Areas about 200 to 400 feet wide and less than one-fourth mile in length band the hillside. These soils are downslope from Sharpsburg and Ladoga soils, and in places, Shelby or Gara soils. They are upslope from other Hesch soils, Montieth soils, and soils on bottom lands. Areas are 5 to 20 acres in size. This soil has the profile described as representative for the series.

Included in mapping are some soils that have a dark-colored surface layer up to 18 inches thick. In places the subsoil has a redder color and cemented sandstone is at a depth of about 40 inches. Thin flags of ironstone are at or near the surface in places. The brownish subsoil is exposed in places, and these areas are indicated on the map by a symbol for a severely eroded spot.

Soil blowing and runoff are hazards if vegetation is sparse. In addition, this soil is droughty and low in fertility. Most areas are in pasture and are suited to this use. A few scattered trees are in places. Some areas have potential for wildlife habitat.

A few small, strongly sloping areas downslope from Ladoga or Sharpsburg soils are cultivated. This soil is generally managed along with surrounding Hesch and Montieth soils. (Capability unit VIIs-1; woodland suitability group 1)

Hesch loam, 9 to 14 percent slopes (417D).—This soil is on the lower part of convex side slopes and on narrow, extended benchlike ridgetops. It is downslope from Shelby and Gara soils. This soil is upslope from other Hesch soils, Montieth soils, or soils on bottom lands. Areas are 5 to 20 acres in size.

This soil has a profile similar to the one described as representative for the series, except that the surface layer is very dark brown or very dark gray loam. Some glacial pebbles or small rocks occur. In places the brownish subsoil is exposed on the surface. These areas are indicated on the map by a symbol for a severely eroded spot.

Included with this soil in mapping are a few areas that have a dark surface layer as much as 18 inches thick.

Runoff erodes this soil if vegetation is sparse. It is droughty and low in fertility.

Most areas are in pasture. Small areas surrounded by Shelby soils are cultivated in places. The soil is suited to pasture and is generally managed along with the Hesch or Montieth soils downslope. (Capability unit VIs-1; woodland suitability group 1)

Hesch loam, 14 to 18 percent slopes (417E).—This soil is on the lower part of convex side slopes. Areas are about 200 to 400 feet wide and band the hillside for a distance of ⅛ to ⅓ mile in places. This soil is downslope from Shelby or Gara soils and, occasionally, from Sharpsburg or Ladoga soils. It is upslope from other Hesch soils, Montieth soils, and soils on bottom lands. Individual areas are about 5 to 40 acres in size.

This soil has a loam surface layer about 10 to 18 inches thick. A few glacial pebbles or small rocks occur. Below this, the soil has a profile similar to the one described as representative for the series.

Included with this soil in mapping are some soils that have a loam or light sandy clay loam subsoil. Also included are some areas where the brownish subsoil is exposed on the surface. These are indicated on the map by a symbol for a severely eroded spot.

Runoff erodes the surface layer if vegetation is sparse. Gullies are in places. Droughtiness and low fertility limit the use of this soil.

All of this soil is used for limited pasture. Scattered trees are in places. Some areas can be developed for wildlife habitat. Some areas are large and are managed as separate fields. Most areas are managed along with the surrounding Hesch and Montieth soils. (Capability unit VIIs-1; woodland suitability group 1)

Humeston Series

The Humeston series consists of deep, dark-colored, poorly drained, silty soils on first and second bottom lands. They are in slight depressions within areas of Zook and Colo soils. Humeston soils are mostly along the bottom lands of Brushy Creek in Seely Township. Individual areas are about 5 to 10 acres in size. Slopes are less than 2 percent.

These soils formed in silty to clayey alluvium about 5 to 20 or more feet thick. Below this, the alluvium is stratified and dominantly sandy. Native vegetation was grasses tolerant to excessive wetness.

In a representative profile, the surface layer is black and very dark gray silt loam about 12 inches thick. The subsurface layer is dark-gray, friable silt loam about 6 inches thick. The subsoil, to a depth of about 60 inches, is mostly firm heavy silty clay loam. It is very dark gray in the upper part and very dark gray to dark gray in the lower part.

Humeston soils have high available moisture capacity. They are moderately permeable in the upper part and very slowly permeable in the lower part. They have a high water table and are saturated during parts of the year unless drained. The surface layer is slightly acid unless limed. Humeston soils are low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Humeston soils are wet, and even if they are artificially drained the surface layer dries out slowly. Water flows onto these soils and is ponded after heavy rains. In most places additional drainage improvements are needed to control surface and subsoil wetness.

These soils are mostly artificially drained and cultivated. They are managed along with the associated Zook and Colo soils.

Representative profile of Humeston silt loam, 390 feet south and 600 feet east of the northwest corner of NE¼NW¼ sec. 14, T. 80 N., R. 32 W., in a nearly level depression on first bottom land:

Ap—0 to 8 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) when dry; cloddy breaking to weak, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A12—8 to 12 inches, very dark gray (10YR 3/1) silt loam, dark gray to gray (10YR 4/1 to 5/1) when dry; weak, medium, platy structure breaking to weak, fine, subangular blocky; friable; slightly acid; clear, smooth boundary.

A2—12 to 18 inches, dark-gray (10YR 4/1) silt loam, light gray (10YR 6/1) when dry; weak, medium, platy structure breaking to weak, very fine, subangular blocky; friable; slightly acid; clear, smooth boundary.

B1g—18 to 23 inches, very dark gray (N 3/0) light silty clay loam; few, fine, distinct, dark yellowish-brown (10YR 3/4) mottles; weak, fine, subangular blocky structure breaking to moderate, fine, subangular blocky; firm; many light-gray (10YR 6/1) silt coatings when dry; slightly acid; gradual, smooth boundary.

B2tg—23 to 37 inches, very dark gray (N 3/0) heavy silty clay loam; moderate, medium, prismatic structure breaking to moderate, medium, subangular blocky; firm; thin nearly continuous clay films; many, fine, soft, dark-brown oxides; slightly acid; diffuse, smooth boundary.

B3tg—37 to 60 inches, very dark gray (10YR 3/1) to dark gray (10YR 4/1) heavy silty clay loam; weak, medium, prismatic structure breaking to moderate, fine and medium, subangular blocky; firm; thin discontinuous clay films; many, fine, dark-brown oxides; slightly acid.

The surface layer is black or very dark gray silt loam or light silty clay loam 10 to 16 inches thick. The subsurface layer is dark-gray or gray, friable silt loam 4 to 8 inches thick. The subsoil is 24 to 50 inches thick. Where the clay content is highest the subsoil is heavy silty clay loam or medium silty clay. It is black or very dark gray in the upper part and very dark gray, dark gray, and gray in the lower part. Mottles of strong brown, yellowish brown, olive, or olive gray are in the lower part of the subsoil in places. The substratum is olive-gray, grayish-brown, or gray, firm heavy silty clay loam or silty clay.

Humeston soils have a thinner subsurface layer and a shallower depth to a more clayey subsoil than Vesser soils. They differ from Zook and Colo soils by having a thinner surface layer and a distinct grayish subsurface layer. They are also more clayey in the lower part of the profile than Colo soils.

Humeston silt loam (0 to 2 percent slopes) (269).—This soil is in slightly depressed areas within areas of Zook and Colo soils on first or second bottoms. Individual areas are typically less than 10 acres in size.

In places this soil has some very dark grayish-brown silt loam or silty clay loam sediment deposited on the surface layer. Some areas have a firm, silty clay subsoil that is less dark colored than that described in the representative profile.

This soil is wet. The water table is high during parts of the year. Water collects on the surface after heavy rains. Field operations are delayed in some years. Much of this soil is artifically drained. It is well suited to row crops if wetness and flooding are controlled. All of this soil is managed with the associated Zook and Colo soils. (Capability unit IIIw-1; woodland suitability group 9)

Judson Series

The Judson series consists of deep, dark-colored, moderately well drained, silty soils on uplands. They are on foot slopes and alluvial fans. Judson soils are downslope from Sharpsburg and Marshall soils and upslope from Nevin, Colo, or Zook soils. Individual areas are 5 to 10 acres in size. Slopes range from 2 to 9 percent.

Judson soils formed in silty alluvium washed from adjacent loess-derived soils on uplands. The silty alluvium is 5 to more than 10 feet thick. Below this, glacial till or loess or, in some places, stratified alluvium occurs. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black and very dark brown light silty clay loam about 27 inches thick. The subsoil, to a depth of about 56 inches, is very dark grayish-brown and brown, friable silty clay loam and heavy silt loam. Some mottles of grayish brown are in the lower part of the subsoil. The substratum is brown and grayish-brown, friable light silty clay loam.

Judson soils have high available water capacity. They are moderately permeable. The water table is at a depth below 3 feet. During short periods of the year, water seeps from soils upslope into the lower part of the subsoil and the substratum of Judson soils. The surface layer is slightly acid unless limed. These soils are medium to low in available nitrogen, low in available phosphorus, and medium in available potassium.

Runoff from soils upslope rills these soils and deposits less fertile sediments on the surface layer in places. The Judson soils are mostly cultivated. A few small areas are in pasture. They are generally managed with the associated soils because individual areas are small in size. Judson soils are among the most productive soils in this county.

Representative profile of Judson silty clay loam, 2 to 5 percent slopes, 205 feet north and 80 feet west of the southeast corner of SW¼SW¼ sec. 35, T. 78 N., R. 32 W., on a foot slope of 3 percent:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam, black (10YR 2/1) to very dark brown (10YR 2/2) when kneaded; cloddy breaking to weak, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) when kneaded; weak, medium, subangular blocky structure breaking to weak, medium, granular; friable; slightly acid; clear, smooth boundary.

A13—15 to 23 inches, very dark brown (10YR 2/2) light silty clay loam, very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) when kneaded; weak, medium, subangular blocky structure breaking to moderate, fine, subangular blocky; friable; slightly acid; clear, smooth boundary.

A3—23 to 27 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) light silty clay loam, very dark grayish brown (10YR 3/2) when crushed; weak, fine, subangular blocky structure breaking to weak, fine, granular; friable; few dark-brown (10YR 3/3) coatings on peds in lower part; neutral; clear, smooth boundary.

B1—27 to 38 inches, very dark grayish-brown (10YR 3/2) and brown (10YR 4/3) light silty clay loam, dark brown (10YR 3/3) when kneaded; weak, medium, prismatic structure to weak, coarse, subangular blocky; friable; nearly continuous very dark grayish-brown (10YR 3/2) coatings on peds; neutral; gradual, smooth boundary.

B2—38 to 47 inches, brown (10YR 4/3) heavy silt loam; moderate, fine and medium, subangular blocky structure; friable; few, medium, distinct, dark-brown (10YR 3/3) coatings on peds; few very dark grayish-brown (10YR 3/2) worm casts; slightly acid; gradual, smooth boundary.

B3—47 to 56 inches, brown (10YR 4/3) heavy silt loam, same when crushed; common, medium, distinct, grayish-brown (2.5Y 5/2) mottles; moderate, medium, subangular blocky structure; friable; few medium sand grains and thin silt coatings; slightly acid; gradual, smooth boundary.

C—56 to 64 inches, brown (10YR 4/3) and grayish-brown (2.5Y 5/2) light silty clay loam, brown (10YR 4/3) when crushed; common dark grayish-brown (10YR 4/2) coatings on peds; some cleavage; friable; few dark reddish-brown (5YR 3/4) concretions; neutral.

The surface layer is black, very dark brown, and very dark grayish-brown, friable light silty clay loam 24 to 36 inches thick. The subsoil is very dark grayish-brown to brown light to medium silty clay loam and heavy silt loam 24 to 30 inches thick. The texture of heavy silt loam is dominant, especially in the lower part. Very dark grayish-brown organic coatings on peds are in the upper part of the subsoil. The substratum ranges from very dark grayish-brown, grayish brown, brown, and dark yellowish-brown to yellowish brown. It is silty clay loam or silt loam. Mottles of olive gray, grayish brown, or strong brown are in the lower part of the subsoil or in the substratum. Judson soils are typically slightly acid but range to medium acid in the subsoil in places. The substratum is slightly acid to neutral.

Judson soils have a browner subsoil than the Ely soils. They are silty rather than loamy in the subsoil as compared with Olmitz soils. Judson soils have a thicker surface layer and a less developed subsoil than the Sharpsburg soils, and they contain less clay in the subsoil. They are not so poorly drained as the Colo soils and lack the grayish-colored subsoil and substratum.

Judson silty clay loam, 2 to 5 percent slopes (8B).—This soil is on low foot slopes and alluvial fans that grade to bottom lands and stream benches. It occurs as bands at the base of Sharpsburg, Marshall, and steeper Judson soils. It is upslope from Nevin, Colo, and Zook soils. Individual areas are generally less than 10 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few areas of Ely soils. In places very dark grayish-brown colors extend to a depth of nearly 40 inches.

This soil receives runoff from soils upslope. Rill erosion occurs in places, and in other areas deposition is common. Generally erosion and deposition are about equal. This soil is well suited to row crops if runoff is controlled. Most of this soil is managed along with the associated soils on stream benches and first bottom lands. (Capability unit IIe-3; woodland suitability group 2)

Judson silty clay loam, 5 to 9 percent slopes (8C).—This soil is on concave, high foot slopes that grade to bottom lands and stream benches. It is downslope from Sharpsburg and Marshall soils and upslope from Nevin, Colo, Zook, and other less sloping Judson soils. Individual areas are 5 to 10 acres in size.

The profile of this soil generally has a thinner surface layer than the profile described as representative for the series. Depth to the brown subsoil is between 24 and 30 inches in most places. The substratum is commonly brown or yellowish brown.

Runoff from soils upslope drains across this soil and causes rills and deposits sediment. Crossable sidehill drainageways are in this soil. This soil is well suited or moderately well suited to row crops if runoff is controlled. Some of this soil is managed along with the soils downslope. A few areas are managed with Sharpsburg soils on side slopes. Areas are small and generally cannot be managed as individual fields. (Capability unit IIIe-1; woodland suitability group 2)

Kennebec Series

The Kennebec series consists of deep, dark-colored, moderately well drained, silty soils on bottom lands. Kennebec soils are associated with Colo, Zook, and Nodaway soils. They are generally at a slightly higher elevation than Colo and Zook soils. Most individual areas range from 5 to 20 acres in size. Slopes range from 0 to 2 percent.

Kennebec soils formed in silty alluvium low in content of sand and 4 to 20 feet thick. Below this is stratified alluvium grading to sand. The sand is typically many feet thick. Native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown and black heavy silt loam and light silty clay loam about 36 inches thick. Below this, the substratum, to a depth of 60 inches, is very dark brown to very dark gray, friable light silty clay loam.

Kennebec soils have high available water capacity. They are moderately permeable. The water table is at a depth below 3 feet. In most places the surface layer is neutral to slightly acid. In some places it is more acid and needs lime. Kennebec soils are medium to low in available nitrogen and medium in available phosphorus and potassium.

These soils are occasionally flooded during periods of high rainfall and runoff. Flooded areas receive deposits of some recent sediments. The Kennebec soils are mostly cultivated. A few small areas adjacent to Alluvial land and Nodaway soils are in pasture. In these places the Kennebec soils are dissected by a noncrossable river or stream in places.

Because areas of Kennebec soils are not large, they are commonly managed along with the associated Colo and Nodaway soils.

Representative profile of Kennebec silt loam, 720 feet south and 390 feet west of the northeast corner of sec. 32, T. 81 N., R. 33 W., on a first bottom of about 1 percent slope:

Ap—0 to 7 inches, very dark brown (10YR 2/2) heavy silt loam, dark gray (10YR 4/1) to dark grayish brown (10YR 4/2) when dry; cloddy breaking to weak, very fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—7 to 23 inches, black (10YR 2/1) heavy silt loam, very dark brown (10YR 2/2) when kneaded, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure breaking to weak, fine and very fine, subangular blocky and moderate, medium, granular; friable; slightly acid; diffuse, smooth boundary.

A13—23 to 36 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) when crushed; weak, fine, subangular blocky structure and moderate, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

C—36 to 60 inches, very dark brown (10YR 2/2) to very dark gray (10YR 3/1) light silty clay loam, very dark brown to very dark grayish brown (10YR 2/2 to 3/2) when crushed; weak, very fine and fine, subangular blocky structure to massive; friable; slightly acid.

The surface layer is black, very dark brown, and very dark gray, friable silt loam or light silty clay loam 30 to 40 inches thick. In places there is 6 to 12 inches of very dark grayish-brown silt loam deposition over the buried surface layer. The substratum is black, very dark brown, very dark grayish-brown, or very dark gray heavy silt loam or light silty clay loam. In places dark grayish-brown silt loam and fine sandy loam strata are at a depth below 40 inches.

Kennebec soils are not so gray in the lower part of the profile or so high in content of clay as the poorly drained Colo soils. They are dark colored to a greater depth than Judson and Olmitz soils and have less sand in the subsoil than the Olmitz soils. Kennebec soils are darker colored to a greater depth than the Nodaway soils and are not stratified.

Kennebec silt loam (0 to 2 percent slopes) (212).—This soil is on bottom lands of major streams and their tributaries. It is associated with Nodaway, Colo, and Zook soils and is at slightly higher elevations than the latter two soils. Areas are irregular in shape and 5 to 20 acres in size.

Included with this soil in mapping are a few areas with as much as 18 inches of recent very dark grayish-brown silt loam deposited on the surface layer. Also included are a few areas that have a light silty loam surface layer.

The use of this soil is generally not limited except by occasional floods after heavy rains. Water drains into this soil readily. If flooding occurs it is usually early in spring before the planting of crops.

This soil is well suited to row crops. Only a few of the larger areas can be managed as individual fields. Most of this soil is managed along with the associated bottom-land soils or soils on low stream benches. (Capability unit I-3; woodland suitability group 8)

Ladoga Series

The Ladoga series consists of deep, moderately dark colored, moderately well drained, silty soils on uplands. They are on convex ridgetops and side slopes. A few areas are on high stream benches where slopes are less than 5 percent. Ladoga soils are upslope from Gara and Armstrong soils and, in places, Shelby and Lindley soils. Individual areas range from 5 to 40 acres in size. Slopes range from 0 to 18 percent.

Ladoga soils formed in loess 10 to 16 feet thick. On parts of side slopes the loess is only 4 feet thick. Below the loess is an old, reddish or grayish, clayey soil 2 to 10 feet thick. Beneath the buried soil is clay loam glacial till 20 to more than 50 feet thick. Areas on stream benches are underlain by an old, red and gray, clayey soil or stratified loamy alluvium many feet thick. The native vegetation was trees and prairie grasses.

In a representative profile the surface layer is black to very dark gray silt loam about 6 inches thick. The subsurface layer is very dark grayish-brown and dark grayish-brown, friable silt loam about 3 inches thick. It is light brownish gray when dry. The subsoil is about 36 inches thick. It is mostly brown and yellowish-brown, firm heavy silty clay loam that grades to light silty clay loam in the lower part. Some mottles of light olive gray are in the lower part of the subsoil. The substratum is brown to yellowish-brown, friable light silty clay loam mottled with light olive gray.

Ladoga soils have high available water capacity. They are moderately slowly permeable. Where there is a water table, it is at a depth below 5 feet. The surface layer is slightly acid to medium acid unless limed. These soils are low in available nitrogen, low to medium in available phosphorus, and medium in available potassium.

Runoff water erodes these soils if they are cleared or vegetation is sparse. Most of the less sloping Ladoga soils have been cleared of trees and are cultivated. Steep areas are in pasture and in a few places they are wooded. A few small areas have good tree cover and can be managed as woodland.

Some of the Ladoga soils occupy entire ridgetops and side slopes and can be managed as individual fields. Some of the more sloping areas are managed as pasture along with Gara soils downslope.

A representative profile of Ladoga silt loam, 5 to 9 percent slopes, moderately eroded, 90 feet north and 180 feet east of the southwest corner of lot 3, or about 1,500 feet south and 1,400 feet east of the northwest corner of sec. 5, T. 78 N., R. 32 W., on a north-facing slope of 7 percent:

A1—0 to 6 inches, black (10YR 2/1) to very dark gray (10YR 3/1) silt loam, very dark gray (10YR 3/1) when kneaded, gray (10YR 5/1) when dry; moderate, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A2—6 to 9 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) silt loam, dark grayish brown (10YR 4/2) when kneaded, light brownish gray (10YR 6/2) when dry; weak, medium, platy structure breaking to moderate, very fine, subangular blocky; friable; very dark gray (10YR 3/1) organic coatings; slightly acid; abrupt, smooth boundary.

B1—9 to 14 inches, brown (10YR 4/3) light silty clay loam, brown (10YR 5/3) when dry; weak, fine, subangular blocky structure; friable; common, very dark gray (10YR 3/1) organic coatings; medium acid; gradual, smooth boundary.

B21t—14 to 19 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) heavy silty clay loam; weak, medium, subangular blocky structure breaking to moderate to strong, fine, angular and subangular blocky; firm; thin, nearly continuous, brown (10YR 4/3) clay films; common, thin, brown (10YR 5/3) silt coatings; medium acid; gradual, smooth boundary.

B22t—19 to 25 inches, yellowish-brown (10YR 5/4) heavy silty clay loam; moderate, medium, subangular blocky structure breaking to moderate, fine, subangular and strong, very fine, angular blocky; firm; thin, nearly continuous, brown (10YR 4/3 to 7.5YR 4/2) clay films; strongly acid; gradual, smooth boundary.

B23t—25 to 32 inches, brown (10YR 5/3) medium silty clay loam; moderate, fine, angular to subangular blocky structure; firm; thin, discontinuous, dark yellowish-brown (10YR 4/4) and brown (7.5YR 4/4) clay films; few black oxides and some grayish-brown silt coatings; strongly acid; gradual, smooth boundary.

B3t—32 to 45 inches, brown (10YR 5/3) light silty clay loam; common, fine to medium, light olive-gray (5Y 6/2) mottles increasing with depth; weak, medium, angular blocky structure; friable; thin discontinuous clay films; common, fine, black oxides; strongly acid; gradual, smooth boundary.

C—45 to 60 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) light silty clay loam; common, fine to medium, light olive-gray (5Y 6/2) mottles; massive; friable; medium acid.

The surface layer is black, very dark gray, or very dark grayish-brown, friable silt loam and ranges from 6 to 10 inches in thickness. The subsurface layer is 0 to 6 inches thick. In cultivated or eroded areas part or most of the subsurface layer is mixed with the plow layer. The subsoil is brown, dark yellowish brown, and yellowish brown. The average clay content in the upper 20 inches of the subsoil is 36 to 40 percent. The subsoil is 2 to 4 feet thick. The substratum is brown, yellowish-brown, and grayish-brown, friable light silty clay loam. Mottles of light olive gray, olive gray, grayish brown, and strong brown are in the lower part of the subsoil and in the substratum. The upper part of the subsoil is medium acid to strongly acid, and the substratum ranges from medium acid to neutral.

Ladoga soils have a thicker or darker colored surface layer than Clinton soils. They have a thinner surface layer than Sharpsburg soils and a grayish subsurface layer. Ladoga soils are silty in the surface layer and subsoil, rather than loamy as are the Lester and Gara soils. They lack the stones and pebbles and reddish colors in the subsoil that are in Armstrong soils.

Ladoga silt loam, 0 to 2 percent slopes (76A).—This soil is on moderately wide, convex ridgetops above more sloping Ladoga soils. In a few places this soil is upslope from more sloping Clinton soils. Individual areas are 5 to 10 acres in size. This soil has a profile similar to that described as representative for the series, except that many areas have a very dark grayish-brown surface layer 9 inches thick.

Included with this soil in mapping are a few areas that have a mottled subsoil. Also included are some Clinton soils that have a dark grayish-brown surface layer.

Nearly all of this soil is cultivated. It is well suited to row crops. There are no serious limitations to farming if management is good. Most areas of this soil are small and are managed along with more sloping Ladoga soils. (Capability unit I-1; woodland suitability group 2)

Ladoga silt loam, 2 to 5 percent slopes (76B).—This soil is on narrow, convex ridgetops and short upper side slopes above more sloping Ladoga soils. In places it is associated with Clinton soils. Individual areas are 5 to 15 acres in size. This soil has a profile similar to the one described as representative for the series. Most areas are cultivated, and the surface layer is very dark grayish brown.

Included with this soil in mapping are a few areas that are shallower to the brownish subsoil.

Runoff erodes this soil if vegetation is sparse. Most areas are cultivated. It is well suited to row crops if erosion is controlled. A few areas are in woods or woods and pasture. Areas not cleared of trees are commonly used for pasture. This soil is managed along with the less sloping Ladoga soils on ridgetops or the more sloping Ladoga soils downslope. (Capability unit IIe-1; woodland suitability group 2)

Ladoga silt loam, 5 to 9 percent slopes (76C).—This soil is on narrow, convex ridgetops and the upper parts of side slopes. It is downslope from the nearly level Ladoga soils and upslope from Gara soils. In places it is upslope from Gara-Armstrong soils. Individual areas are 5 to 20 acres in size.

This soil has a profile similar to the one described as representative for the series, but the surface layer is very dark gray, friable silt loam about 9 inches thick.

Runoff erodes this soil if it is cleared of trees and vegetation is sparse. Some of this soil is in pasture or woods and pasture. It is well suited or moderately well suited to row crops if erosion is controlled. Small areas or narrow, irregular-sized areas are generally used for pasture if surrounded by steeper soils. Areas cleared of trees are cultivated. (Capability unit IIIe-1; woodland suitability group 2)

Ladoga silt loam, 5 to 9 percent slopes, moderately eroded (76C2).—This soil is on narrow, convex ridgetops and the upper parts of side slopes. It is downslope from other less sloping Ladoga soils and above Gara soils. It is upslope from Gara-Armstrong soils in places. It is the most extensive Ladoga soil in the county. Areas range from 5 to 20 acres in size. This soil has the profile described as representative for the series.

Most of this soil is cultivated and has a very dark grayish-brown plow layer. In many places, the brown subsoil is mixed with the surface layer by plowing. In a few eroded areas the brownish subsoil is exposed on the surface. These spots have poor tilth and are more difficult to work.

Runoff erodes this soil if vegetation is sparse. It is moderately well suited to row crops if erosion is controlled. Some of this soil has crossable sidehill drainageways. Young trees and shrubs grow along these drainageways unless controlled. Most of this soil is managed along with the less sloping Ladoga soils upslope. A few areas

are large and can be managed as individual fields. (Capability unit IIIe-1; woodland suitability group 2)

Ladoga silt loam, 9 to 14 percent slopes (76D).—This soil is on the upper half of convex side slopes below less sloping Ladoga soils. It is upslope from Gara and Gara-Armstrong soils. Individual areas are generally 5 to 10 acres in size.

This soil has a profile similar to the one described as representative for the series, but the lower part of the subsoil and the substratum are commonly more mottled. This soil is generally slightly acid at a depth of about 3 feet and below. The surface layer erodes if vegetation is sparse.

Nearly all of this soil is in pasture or woods and pasture. Areas cleared of trees are moderately well suited to row crops if erosion is controlled. The tree cover in wooded areas is generally not dense, and most wooded areas are pastured. A few small areas can be managed as woodland. This land is partly dissected by sidehill gullies and drainageways. Some are noncrossable. Young trees and shrubs grow along these drainageways unless controlled. A few cleared areas are managed along with less sloping Ladoga soils on side slopes. Most of the acreage is managed as pasture along with the steeper Gara soils downslope. (Capability unit IIIe-2; woodland suitability group 2)

Ladoga silt loam, 9 to 14 percent slopes, moderately eroded (76D2).—This soil is on the upper half of convex side slopes below less sloping Ladoga soils. It is upslope from Gara soils. Individual areas are 5 to 20 acres or more in size.

This soil has a very dark grayish-brown surface layer immediately underlain by the brownish subsoil. In cultivated areas the grayish subsurface layer is mixed with the plow layer. In some places the brownish subsoil is exposed on the surface. These areas are indicated on the soil map by a symbol for severely eroded spots. Areas of this soil in the western part of the county have slightly less clay in the subsoil than those in the southeastern part.

Runoff erodes this soil if vegetation is sparse. Severely eroded spots have poor tilth and are more difficult to work.

Most of this soil is cultivated. It is moderately well suited to row crops if erosion is controlled. Sidehill drainageways and some gullies occur. Young trees and shrubs grow along these drainageways unless controlled. Some of this soil is in areas large enough to be managed as individual fields. Other areas are managed along with the less sloping Ladoga soils upslope. (Capability unit IIIe-2; woodland suitability group 2)

Ladoga silt loam, 14 to 18 percent slopes, moderately eroded (76E2).—This soil is on the upper part of convex side slopes above Gara soils. It is downslope from other less sloping Ladoga soils. In a few places it occupies the entire side slope and grades downslope to Colo-Judson soils in drainageways. Individual areas are 5 to 15 acres in size.

This soil has a surface layer of very dark grayish-brown, friable silt loam in most places. The grayish subsurface layer is thin or, in cultivated areas, is mixed with the plow layer. The subsoil is thinner than that in the profile described as representative for the series. The slightly acid substratum is at a depth of about 3 feet. In a few places the brownish subsoil is at the surface. These places are indicated on the soil map by the symbol for a severely eroded spot.

Runoff erodes this soil if vegetation is sparse or it is cultivated. Most of this soil is cultivated or has been in the past. It is cleared of trees. This soil is poorly suited to row crops even if erosion is controlled. A few areas are in woods or woods and pasture. These are managed as pasture, but a few can be managed as woodlands. Sidehill drainageways and gullies occur. Young trees and shrubs grow along these drainageways unless controlled. Because individual areas are small, most of this soil is managed along with the Gara soils downslope. (Capability unit IVe-2; woodland suitability group 2)

Ladoga silt loam, benches, 2 to 5 percent slopes (T76B).—This soil is on convex, high stream benches below steeper loess- and till-derived soils. It is above Colo, Zook, and Nevin soils. Individual areas are only 5 to 15 acres in size.

This soil has a profile similar to the one described as representative for the series, except that most of it is plowed and has a very dark grayish-brown surface layer. In places there are no grayish mottles in the lower part of the subsoil. The loess in which this soil formed is about 10 to 12 feet thick. This is underlain by an old, red or gray, clayey soil over stratified loamy to sandy alluvium several feet thick. In places the old, clayey soil is lacking.

Runoff erodes this soil if the surface is bare or vegetation is sparse. In places runoff from soils upslope drain onto this soil. Sediments are deposited at the base of upland slopes and stream benches.

Nearly all of this soil is cultivated. It is well suited to cultivation if runoff and erosion are controlled. Small areas of this soil are managed along with soils on first and second bottoms. (Capability unit IIe-1; woodland suitability group 2)

Lamoni Series

The Lamoni series consists of deep, dark-colored, somewhat poorly drained soils on uplands. The subsoil is clayey. These soils are on the lower part of convex side slopes or head slopes formed by branching, upland drainageways. Lamoni soils are downslope from Sharpsburg, Ladoga, and Clearfield soils. The Colo-Judson complex or Shelby soils are downslope. Individual areas are 5 to 20 acres in size. Slopes range from 9 to 18 percent.

Lamoni soils formed in parts of an old, gray, clayey soil formed during an earlier geologic period. The old soil formed in clay loam glacial till. Most of it was buried by loess. In time, the loess and part of the buried soil were removed by geologic erosion, and a new soil began to form. The part of the old, gray, clayey subsoil that remained became the subsoil of the newly formed Lamoni soil. Below this clayey subsoil is 20 to more than 50 feet of clay loam glacial till. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black silty clay loam about 8 inches thick. Below this is very dark grayish-brown, firm heavy clay loam about 6 inches thick. The subsoil extends to a depth of about 45 inches and is mottled, dark grayish-brown, firm clay and heavy

clay loam in the upper part and mottled, yellowish-brown, firm clay loam in the lower part. Below this, the substratum is mottled, yellowish-brown, firm clay loam. A few stones and pebbles are in the subsoil and substratum.

Lamoni soils have high available water capacity. They are slowly permeable. They are saturated during parts of the year and receive seepage water from soils upslope. The surface layer is slightly acid unless limed. These soils are low in available nitrogen and phosphorus and low to medium in available potassium.

These soils are eroded by runoff if vegetation is sparse. Most of the Lamoni soils are cultivated or have been cultivated in the past. Steeper areas are used for pasture.

Areas vary in size but most are small or narrow and are managed along with Shelby soils downslope.

Representative profile of Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded, 216 feet south and 310 feet east of the northwest corner of NE¼ sec. 33, T. 79 N., R. 31 W., on a south-facing slope of 10 percent:

Ap—0 to 8 inches, black (10YR 2/1) medium silty clay loam; cloddy breaking to fine and very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

AB—8 to 14 inches, 70 percent very dark grayish-brown (2.5Y 3/2) and 30 percent dark grayish-brown (2.5Y 4/2) heavy clay loam, very dark grayish brown (2.5Y 3/2) when kneaded; weak, medium, subangular blocky structure; firm; nearly continuous very dark gray organic coatings; slightly acid; clear, smooth boundary.

B21t—14 to 20 inches, dark grayish-brown (2.5Y 4/2) clay; common, fine, distinct, olive-brown (2.5Y 4/4) mottles; weak to moderate, medium, subangular blocky structure; firm; thick, discontinuous, dark-gray clay films; few pebbles and sand grains; slightly acid; clear, smooth boundary.

B22t—20 to 25 inches, dark grayish-brown (2.5Y 4/2) heavy clay loam; common, medium, prominent, yellowish-brown (10YR 5/6 and 5/8) mottles; weak, medium and coarse, subangular blocky structure; firm; thick, discontinuous, gray clay films; few pebbles; neutral; clear, smooth boundary.

B31t—25 to 37 inches, yellowish-brown (10YR 5/8) and coarsely mottled light-gray (10YR 6/1 to N 6/0) medium to heavy clay loam; weak, medium, prismatic structure breaking to weak, medium, subangular blocky; firm; thin discontinuous clay films; some pebbles; neutral; clear, smooth boundary.

B32t—37 to 45 inches, yellowish-brown (10YR 5/6) medium clay loam; common, medium, light-gray (10YR 6/1 to N 6/0) mottles; weak, medium, prismatic structure breaking to weak, medium, subangular blocky; firm; thin discontinuous clay films; common pebbles; some lime concretions; mildly alkaline; gradual, smooth boundary.

C—45 to 60 inches, yellowish-brown (10YR 5/8) light to medium clay loam; many, medium, prominent, light-gray (10YR 6/1 to N 6/0) mottles; massive; firm; common pebbles; strongly effervescent; mildly alkaline.

The surface layer of uneroded soils is black or very dark gray, friable silty clay loam or clay loam 10 to 16 inches thick. In most places there is a transitional layer of very dark grayish-brown, firm clay loam between the surface layer and the subsoil. The subsoil is 2 to 3 feet thick. It is dark grayish brown, 10YR or 2.5Y in hue, in the upper 6 to 12 inches and grayish brown to yellowish brown or dark yellowish brown in the lower part. Mottles of olive gray, olive brown, gray, light gray, yellowish brown, or strong brown are in the subsoil. The subsoil is firm clay or heavy clay loam, but it contains less clay in the lower part. The substratum is dark yellowish-brown or yellowish-brown, firm light to medium clay loam. Mottles of olive gray, gray, or light gray are in the substratum. The upper part of the subsoil is medium to slightly acid. The lower part of the subsoil and the substratum are neutral to mildly alkaline. Free lime is commonly at a depth between 3 and 4 feet.

Lamoni soils have a thinner, less gray subsoil than the poorly drained Clarinda soils. They lack the reddish colors that are in the subsoil of Adair soils. They are higher in clay and firmer in the subsoil than Nicollet soils. Lamoni soils contain some sand and pebbles in the subsoil and substratum that are lacking in the loess-derived Macksburg soils.

Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded (822D2).—This soil is on the lower part of convex side slopes and on head slopes formed by branching upland drainageways. It is downslope from Sharpsburg soils and, in places, from Clearfield soils. It is above Shelby soils or Colo-Judson soils in narrow drainageways. Most areas are less than 10 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are about 80 acres of a soil that is severely eroded. Also included are areas where the grayish, clayey subsoil is exposed on the surface or mixed with he plow layer. These spots have poor tilth and are difficult to till. They are indicated on the soil map by the symbol for severely eroded spots.

Runoff erodes this soil if vegetation is sparse. This soil is also somewhat wet during periods of high rainfall, and the surface layer dries slowly.

Much of this soil has been cultivated in the past. Small areas are now cultivated along with associated soils. This soil is poorly suited to row crops even if erosion is controlled. Sidehill drainageways are common and runoff control is needed to prevent gullying. In places, the loess soils upslope are tile drained to intercept the water that seeps onto this soil. Areas associated with steeper Shelby soils downslope are used for pasture. (Capability unit IVe-1; woodland suitability group 7)

Lamoni silty clay loam, 14 to 18 percent slopes, moderately eroded (822E2).—This soil is on lower parts of head slopes and in bands on side slopes below Sharpsburg soils but upslope from Shelby soils. Individual areas are 5 to as much as 20 acres in size.

Included with this soil in mapping are areas that are severely gullied. Also included are some severely eroded areas. They are indicated on the map by the symbol for severe erosion. These spots have poor tilth and are difficult to work. Also included are about 100 acres of a soil that has a thicker, clayey subsoil.

Runoff erodes this soil if vegetation is sparse. It is somewhat wet during periods of high rainfall, and the surface layer dries slowly after rains.

Most of this soil is in pasture. A few small areas associated with less sloping land are cultivated. Sidehill drainageways are common, and runoff control is needed to prevent gullying. This soil is suited to pasture. Some gullied areas need to be shaped before tillage equipment can be used. Some small areas are used for wildlife habitat. (Capability unit VIe-1; woodland suitability group 7)

Lester Series

The Lester series consists of deep, moderately dark colored, well-drained, loamy soils on uplands. Small stones and pebbles are common in these soils. They are on

convex ridgetops and side slopes. These soils are parallel to stream valleys in the northeastern part of the county. Individual areas are 5 to 20 acres in size.

Lester soils formed in loam glacial till that is 20 feet or more in thickness. On steeper soils adjacent to streams the till is thinner. Beneath the loam till are stratified loamy sediments, silts, or a buried, clayey soil and clay loam till in places. In most places the loam till is underlain by a few feet of stratified sediments and up to 50 feet or more of clay loam till. The native vegetation was trees and prairie grasses.

In a representative profile, the surface layer is black loam about 6 inches thick. It is underlain by a subsurface layer of dark grayish-brown, friable loam about 5 inches thick. The subsoil, to a depth of 52 inches, is brown to yellowish-brown, friable light to medium clay loam. If the soil is excavated to a depth greater than 52 inches, the substratum is described as yellowish-brown, friable loam mottled with some gray and strong brown.

Lester soils have high available water capacity. They are moderately permeable. The water table is at a depth below 6 feet. The surface layer is generally slightly acid, but some areas are more acid unless limed. These soils are low to very low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Many areas of the Lester soils are wooded or are in pasture and woods. Other areas are cleared of trees and cultivated. These sloping soils erode if vegetation is sparse. Sidehill drainageways are common on the more sloping Lester soils. Runoff needs to be controlled to prevent gullying. Small stock ponds or erosion control structures are built on these soils in places.

Because many areas are small and irregular in size, they are managed along with the associated Clarion and Storden soils.

Representative profile of Lester loam, 5 to 9 percent slopes, moderately eroded, 297 feet north and 58 feet west of the southeast corner of the NE¼SW¼ sec. 10, T. 79 N., R. 30 W., on a northeast-facing slope of 7 percent:

A1—0 to 6 inches, black (10YR 2/1) heavy loam, dark gray (10YR 4/1) when dry; moderate, fine, subangular blocky structure breaking to moderate, fine, granular; friable; slightly acid; clear, smooth boundary.

A2—6 to 11 inches, dark grayish-brown (10YR 4/2) heavy loam, light grayish brown (10YR 6/2) when dry; faces of peds very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1); moderate, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B21t—11 to 17 inches, brown (10YR 4/3) light clay loam; moderate, fine, subangular blocky structure; friable; thin discontinuous clay films; few grayish silt coatings; some pebbles; medium acid; gradual, smooth boundary.

B22t—17 to 31 inches, brown (10YR 4/3) light to medium clay loam; moderate, medium, subangular blocky structure; friable; thin discontinuous clay films; some pebbles; slightly acid; gradual, smooth boundary.

B3—31 to 52 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) light clay loam; weak, medium, subangular blocky structure; friable; few, medium, distinct, strong-brown (7.5YR 5/6), soft concretions; some pebbles; neutral.

The surface layer is black, very dark gray, or very dark grayish-brown, friable loam 6 to 10 inches thick. The subsurface layer is dark grayish-brown, friable loam 2 to 6 inches thick. In eroded or cultivated areas much of this layer is mixed with the surface layer. The subsoil is brown, dark yellowish-brown, and yellowish-brown light to medium clay loam. It is generally 2½ to 3½ feet thick. The lower part of the subsoil and the substratum are slightly acid to mildly alkaline. Depth to carbonates ranges from 3 to 4½ feet.

Lester soils have less clay in the subsoil and substratum than Gara soils. They have a thinner surface layer than Clarion soils and a grayish subsurface layer. Lester soils have a lower clay content in the subsoil than the Ladoga soils and are loamy rather than silty.

Lester loam, 2 to 5 percent slopes (236B).—This soil is on slightly undulating convex ridgetops upslope from steeper Lester soils. In places, it is on similar landscapes to those occupied by Clarion soils. Individual areas are generally less than 15 acres in size. This soil has a profile similar to the one described as representative for the series, but the surface layer is as much as 10 inches thick in places.

Included with this soil in mapping are a few areas that have a dark grayish-brown surface layer.

Most of this soil is cleared of trees and cultivated. It is well suited to row crops if erosion is controlled. Areas in pasture are generally partly wooded. Small areas are managed along with the more sloping Lester soils downslope. (Capability unit IIe-2; woodland suitability group 3)

Lester loam, 5 to 9 percent slopes, moderately eroded (236C2).—Most of this soil is on short, convex side slopes, but a few areas are on narrow ridgetops. This soil is both upslope and downslope from other Lester soils. Individual areas are about 5 to 10 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are about 150 acres of a soil that has a dark grayish-brown surface layer. In some cultivated areas the surface layer is very dark gray or very dark grayish brown.

Much of this soil is cleared of trees and cultivated. This soil is well suited or moderately well suited to row crops if erosion is controlled. Some areas are in woods or woods and pasture. Small wooded areas are excellent habitat for wildlife. (Capability unit IIIe-3; woodland suitability group 3)

Lester loam, 9 to 14 percent slopes, moderately eroded (236D2).—This soil is on short, convex side slopes. Sidehill drainageways are common. This soil is downslope from less sloping Lester soils and upslope from soils on bottom lands. Individual areas are variable in size but are generally less than 20 acres. This soil has a profile similar to the one described as representative for the series, but the subsoil is about 2 feet thick.

Included with this soil in mapping are about 75 acres of a soil that has a thin, dark grayish-brown surface layer. Also included are small severely eroded areas where the brownish subsoil is exposed on the surface. These places are indicated on the map by a symbol for severely eroded spots.

About half or more of this soil is cleared of trees and cultivated. It is only moderately well suited to row crops even if erosion is controlled. Severely eroded spots have poor tilth and are somewhat difficult to work. Gullies form in sidehill drainageways unless runoff is controlled. The remaining areas are in woods or in woods and pasture. Areas not cleared are generally used for pasture. Some can be managed as woodland and others make excellent habitat for wildlife. Most of this land is managed

along with less sloping Lester soils. (Capability unit IIIe-4; woodland suitability group 3)

Lindley Series

The Lindley series consists of deep, light-colored, moderately well drained, loamy soils on uplands. Small stones and pebbles are common in these soils. These soils are on convex side slopes. Individual areas range from 5 to 40 acres in size. Slopes range from 14 to 40 percent.

These soils formed in clay loam glacial till that is 20 to more than 50 feet thick in places. Below this is sandstone, shale, limestone, or a buried, gray, clayey soil and many more feet of glacial till. The latter is most common. The native vegetation was deciduous trees.

In a representative profile, the surface layer is very dark gray loam about 3 inches thick. It is distinctly lighter colored when dry. The subsurface layer is dark grayish-brown to gray, friable loam about 6 inches thick. Below this, the subsoil is brown, dark yellowish-brown, and yellowish-brown, firm clay loam mottled with grayish brown and strong brown in the lower part. The subsoil extends to a depth of about 43 inches and is underlain by a substratum of mottled, grayish-brown and yellowish-brown, firm clay loam.

These soils have high available water capacity. They are moderately slowly permeable. The water table is at a depth below 6 feet and generally much deeper. The surface layer is slightly acid, and some areas are more acid unless limed.

They are very low to low in available nitrogen and phosphorus and low to medium in available potassium.

These soils are eroded by runoff if vegetation is sparse. Gullies form in sidehill drainageways in places. Severely eroded spots are more difficult to till.

Some of the less sloping soils have been cultivated in the past. Most areas are in pasture or in woods and pasture. These soils generally determine the use and management of the associated soils on side slopes.

Representative profile of Lindley loam, 25 to 40 percent slopes, moderately eroded, 700 feet north (765 feet along winding road) and 500 feet east of the southwest corner of SE¼SW¼ sec. 15, T. 79 N., R. 30 W., on a west-facing slope of 30 percent:

A1—0 to 3 inches, very dark gray (10YR 3/1) loam, gray (10YR 5/1) when dry; weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

A21—3 to 5 inches, dark grayish-brown (10YR 4/2) to dark-gray (10YR 4/1) loam, light gray (10YR 6/1) when dry; weak, medium, platy structure breaking to weak, medium, granular; friable; slightly acid; abrupt, smooth boundary.

A22—5 to 9 inches, dark grayish-brown (10YR 4/2) to grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when kneaded, light gray (10YR 7/2) when dry; very weak, very fine, subangular blocky structure; friable; strongly acid; clear, smooth boundary.

B1—9 to 14 inches, brown (10YR 4/3) medium clay loam; moderate, very fine, subangular and angular blocky structure; firm; nearly continuous dark grayish-brown silt coatings; some pebbles; strongly acid; diffuse, smooth boundary.

B21t—14 to 22 inches, brown (10YR 4/3) to yellowish-brown (10YR 5/4) heavy clay loam; moderate, fine and medium, angular and subangular blocky structure; firm; thin, continuous, brown (10YR 4/3) clay films; some pebbles; strongly acid; gradual, smooth boundary.

B22t—22 to 29 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) medium clay loam; very few, fine, grayish-brown (10YR 5/2) mottles and few, medium, strong-brown (7.5YR 5/6) mottles; moderate, medium, subangular blocky structure; firm; thin, discontinuous, brown (10YR 4/3) clay films; few pebbles; medium acid; gradual, smooth boundary.

B23t—29 to 36 inches, mottled yellowish-brown (10YR 5/4) and grayish-brown (10YR 5/2) medium clay loam; moderate, fine, subangular and angular blocky structure; firm; thin, discontinuous, brown (10YR 4/3) clay films; some pebbles; medium acid; clear, smooth boundary.

B3t—36 to 43 inches, mottled brown (10YR 5/3), yellowish-brown (10YR 5/6), and grayish-brown (10YR 5/2) medium clay loam; weak, medium, subangular blocky structure; firm; thick very dark grayish-brown clay flows and few, thin, discontinuous clay films; thin horizontal band of soft lime concretions; some pebbles; strongly effervescent; mildly alkaline; clear, smooth boundary.

C—43 to 60 inches, mottled, grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/6) light to medium clay loam; massive; firm; few, soft, lime concretions; few, fine, soft, dark-brown oxides; some pebbles; strongly effervescent; mildly alkaline.

The surface layer in uneroded or noncultivated areas is very dark gray or very dark grayish-brown, friable loam 1 to 5 inches thick. If cultivated, the plow layer is dark grayish brown. The subsurface layer is dark-gray, dark grayish-brown, or brown, friable loam 4 to 8 inches thick. The subsoil is 2 to 3 feet thick and ranges from light to heavy clay loam. Mottles of grayish brown and strong brown are in the subsoil and increase in size and abundance as depth increases. The substratum is mottled grayish-brown, olive-gray and yellowish-brown, firm light to medium clay loam. The upper part of the subsoil is medium acid to very strongly acid, and the lower part of the subsoil and the substratum are slightly acid to mildly alkaline. Carbonates are at a depth between 30 and 48 inches.

Lindley soils have a thinner or less dark surface layer and a thicker, more distinct subsurface layer than Gara or Lester soils. The subsoil and substratum of Lindley soils are also firmer and slightly higher in clay than those of Lester soils. Lindley soils have less clay in the subsoil than Clinton soils and are loamy rather than silty.

Lindley loam, 14 to 18 percent slopes, moderately eroded (65E2).—This soil is on the lower half of convex side slopes downslope from Clinton soils and upslope from bottom lands or soils in narrow drainageways. Individual areas range from 5 to 20 acres in size.

This soil has a profile similar to the one described as representative for the series, but the surface layer is generally dark grayish brown. About half of the acreage of this soil is severely eroded, and in these places the brownish subsoil is exposed on the surface.

Runoff erodes this soil if vegetation is sparse, and sidehill drainageways form gullies in places. Although most areas are cleared of trees, trees and brush readily grow along drainageways and gullies unless controlled. Farm ponds or erosion control structures are built on this soil or in narrow drainageways adjacent to it.

Much of this soil is used for pasture. It is suited to pasture and generally is managed along with the steep Clinton soils upslope and the Colo-Judson soils downslope. Timbered areas can be managed as woodland or as habitat for wildlife. (Capability unit VIe-2; woodland suitability group 3)

Lindley loam, 18 to 25 percent slopes, moderately eroded (65F2).—This soil occupies entire convex side slopes

and the lower half of head slopes near major streams. It is upslope from bottom lands and Olmitz-Colo, channeled, soils in drainageways and downslope from Clinton soils. Individual areas are as much as 40 acres in size.

Included with this soil in mapping on the upper parts of slopes are small, narrow bands of soils that have a reddish clayey subsoil. These soils are indicated on the map by a symbol for a reddish, clayey spot.

Runoff is very rapid on this sloping soil, and the surface erodes and gullies form if vegetation is sparse. Sidehill drainageways are common and generally crossable. Farm ponds or erosion control structures are built on this soil or in narrow drainageways downslope from this soil.

All of this soil is in pasture or woods and pasture. It is suited to pasture, but trees and shrubs encroach on cleared areas unless controlled. Farm equipment can be used to renovate pastures, but some gullies are safety hazards. Areas are generally large and can be managed as separate fields. (Capability unit VIIe-1; woodland suitability group 4 or 5)

Lindley loam, 25 to 40 percent slopes, moderately eroded (65G2).—This soil occupies entire convex side slopes or the major part of side slopes. Many sidehill drainageways and gullies occur. Individual areas are generally 5 to 20 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few eroded areas where the brownish subsoil is exposed on the surface. These are indicated on the map by a symbol for a severely eroded spot. In some places the subsoil is 18 to 30 inches thick. In places grayish-brown mottles are at a shallower depth than typical.

Runoff is very rapid, and the surface layer erodes if vegetation is sparse. Trees and shrubs encroach on cleared land unless controlled. Farm ponds or erosion control structures are built on this soil or in narrow drainageways downslope. Using tillage equipment is hazardous because of steep soils and the occurrence of many noncrossable gullies.

Some areas of this soil have been cleared or partly cleared of trees and are in pasture. Areas that have a dense stand of trees can be managed as woodland or as habitat for wildlife. Most of this soil is managed as pasture along with less sloping Lindley soils on side slopes and Olmitz-Colo complex, channeled, downslope. (Capability unit VIIe-1; woodland suitability group 4 or 5)

Lindley soils, 18 to 25 percent slopes, severely eroded (65F3).—This unit is on parts of convex side slopes. It is downslope from Clinton soils and it is associated with less eroded Lindley soils on side slopes. Individual areas are generally 5 to 10 acres in size.

The profile of this soil differs from the profile described as representative for the series in that most of the original loam surface layer has been removed by erosion. The present surface layer is brown or dark grayish-brown loam or clay loam.

Tilth is poor. Much of the water that falls on the surface runs off and continues to erode this soil if vegetation is sparse. Gullies form rapidly and must be filled and shaped before tillage equipment can be used.

All of this land has been cleared of trees. Much of it has been cultivated in the past. It is suited to pasture, woodland, and as habitat for wildlife. Trees and shrubs grow readily in pasture areas unless controlled. The trees can be harvested or managed for habitat for wildlife. Most areas are small in size and are managed with the adjoining less eroded Lindley soils on side slopes. (Capability unit VIIe-1; woodland suitability group 4 or 5)

Macksburg Series

The Macksburg series consists of deep, dark-colored, somewhat poorly drained, silty soils on uplands. They are on slightly convex, broad ridgetops and divides. They are only in the southeastern part of the county. Individual areas range from 20 to about 80 acres in size. Slopes range from 0 to 2 percent.

These soils formed in loess 10 to about 16 feet thick. Below the loess is an old, buried, gray, clayey soil 6 to 10 feet thick. Beneath this old soil is clay loam glacial till 20 to more than 50 feet thick. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black and very dark grayish-brown light to medium silty clay loam about 23 inches thick. The subsoil, to a depth of about 50 inches, is dark grayish-brown, brown, yellowish-brown, and grayish-brown, firm heavy silty clay loam grading to friable medium silty clay loam at a depth of about 3 feet. Beneath this, the substratum is light brownish-gray, friable light silty clay loam. Grayish and brownish mottles are in the subsoil and substratum.

Macksburg soils have high available water capacity. They are moderately slowly permeable. A perched water table is at a depth of about 2 to 4 feet during parts of the year. The surface layer is medium acid unless limed. These soils are low to medium in available nitrogen and phosphorus and medium to high in available potassium.

Macksburg soils are slightly wet during periods of high rainfall. Most of the water that falls on the surface is absorbed and does not run off. These soils dry out somewhat slowly after rains, and field operations are delayed for a few days.

Most of these soils are cultivated. Some areas are large enough to be managed as separate fields. Most areas are cropped along with the adjacent Sharpsburg soils.

Representative profile of Macksburg silty clay loam, 400 feet south and 300 feet east of the northwest corner of SW¼NW¼ sec. 36, T. 78 N., R. 30 W., on an upland divide of 1 percent slope:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam; moderate, fine and medium, granular structure; friable; medium acid; clear, smooth boundary.

A12—7 to 13 inches, black (10YR 2/1) light silty clay loam; moderate, medium and fine, granular structure; friable; medium acid; clear, smooth boundary.

A13—13 to 18 inches, black (10YR 2/1) light to medium silty clay loam; moderate, fine and medium, granular structure; friable; medium acid; clear, smooth boundary.

A3—18 to 23 inches, very dark grayish-brown (10YR 3/2) medium silty clay loam, very dark grayish brown (10YR 3/2) when kneaded; faces of peds black (10YR 2/1) to very dark brown (10YR 2/2); moderate, fine breaking to moderate, very fine, subangular blocky structure; friable; medium acid; clear, smooth boundary.

B21t—23 to 29 inches, dark grayish-brown (10YR 4/2) and brown (10YR 4/3) medium to heavy silty clay loam; faces of peds dark grayish brown (10YR 4/2) and very dark grayish brown (10YR 3/2); weak, fine,

prismatic structure breaking to moderate, fine and very fine, subangular blocky; firm; thin, discontinuous clay films; medium acid; clear, smooth boundary.

B22t—29 to 36 inches, brown (10YR 4/3) to yellowish-brown (10YR 5/4) medium to heavy silty clay loam; faces of peds dark grayish brown (10YR 4/2); common, fine, grayish-brown (10YR 5/2) mottles; weak, medium, prismatic structure breaking to moderate, fine, subangular blocky; firm; thin, discontinuous clay films; common very dark gray (10YR 3/1) fills in root and worm channels; slightly acid; gradual, smooth boundary.

B3t—36 to 50 inches, grayish-brown (10YR 5/2) medium silty clay loam; many, fine and medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, prismatic structure breaking to weak, medium and coarse, subangular blocky; friable; few, thin, discontinuous clay films, roots common to a depth of 46 inches; neutral; gradual, smooth boundary.

C—50 to 72 inches, light brownish-gray (10YR 6/2 to 2.5Y 6/2) light silty clay loam; many, medium, yellowish-brown (10YR 5/8) mottles; friable; strong-brown layer at a depth of 60 inches, common pores; neutral.

The surface layer is black, friable light to medium silty clay loam 16 to 24 inches thick. The lower part of the surface layer is very dark grayish brown. The subsoil ranges from firm heavy silty clay loam in the upper part to friable medium silty clay loam in the lower part. It is 2 to 3 feet thick and dark grayish brown, brown, light brownish gray, and yellowish brown. The grayish colors are dominant in the lower part. The substratum ranges from yellowish-brown or grayish-brown to light brownish-gray light silty clay loam. These soils are typically medium acid in the upper part of the subsoil and slightly acid to neutral at a depth of 2 to 3 feet and below.

Macksburg soils have a thicker surface layer and a more mottled subsoil than Sharpsburg soils. They do not have a gray subsoil that is underlain by a gray, clayey, buried soil as do Clearfield soils.

Macksburg silty clay loam (0 to 2 percent slopes) (368).—This soil is on broad, convex ridgetops and divides surrounded by Sharpsburg soils. Individual areas are generally large.

Included with this soil in mapping are a few small areas that have a gray subsoil.

This soil is slightly wet during periods of heavy rainfall. This delays field operations but does not affect crop growth. Only a few small areas of the included soil need tile drainage. Most of the water that falls on the surface is absorbed.

All of the soil is cultivated. It is well suited to row crops. This is one of the most desirable soils in the county for farming. Some areas are large and can be managed as separate fields. Other areas are managed along with the adjacent nearly level or gently sloping Sharpsburg soils. (Capability unit I-1; woodland suitability group 6)

Marsh

Marsh (0 to 1 percent slopes) (354) consists of depressional areas covered by 1 to 3 feet of water during parts of the year. All of this miscellaneous land type is in the northeastern part of the county. During periods of low rainfall the water area disappears or decreases in size, and dense swamp vegetation begins to grow around the perimeter of the marsh. By fall the marsh is covered with cattails, swamp grasses, and weeds.

The basin of the depression contains dark silty alluvium. Around the rim of the depression, 6 to 10 inches of muck or partly decayed plant residue is on the surface.

This miscellaneous land type is not artificially drained. In places open ditches outlet into the marsh. Marsh is well suited to habitat for wildlife. Many of the areas have been set aside as game refuges and public hunting grounds. (Capability unit VIIw-1; woodland suitability group 9)

Marshall Series

The Marshall series consists of deep, dark-colored, well-drained, silty soils on uplands. They are on narrow, convex ridgetops and on side slopes. Slopes range from 2 to 14 percent. A few areas are on high stream benches where slopes range from 2 to 5 percent. These soils are only in the northwestern part of the county. They are mainly in Orange Township and in the northern part of Union and Highland Townships.

Marshall soils formed in loess about 20 feet thick. The loess is somewhat thinner on side slopes. Beneath the loess on uplands a buried, red or gray, clayey soil 1 to about 6 feet thick is underlain by clay loam till up to 50 feet or more thick. On benches, the loess is underlain by stratified loamy sediments many feet thick. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown light silty clay loam about 15 inches thick. The subsoil is brown, friable light to medium silty clay loam about 30 inches thick. Beneath this, the substratum is mottled, yellowish-brown, friable silt loam.

Marshall soils have high available water capacity and are moderately permeable. The water table is at a depth below 6 feet and generally much deeper. The surface layer is slightly acid or, in places, medium acid unless limed. They are low to medium in available nitrogen and available phosphorus and medium to high in available potassium. The less sloping Marshall soils are among the most productive soils in the county.

Many of the Marshall soils are cultivated. Runoff water rills and gullies these soils if vegetation is sparse. Sidehill drainageways are common on the more sloping soils.

Most of these soils can be managed as individual fields. Some of the more sloping soils are managed along with Shelby or Shelby-Adair soils downslope.

Representative profile of Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded, 270 feet south and 36 feet east of the northwest corner of sec. 18, T. 81 N., R. 33 W., on a southeast-facing slope of 3 percent:

A1—0 to 10 inches, very dark brown (10YR 2/2) light silty clay loam; weak, fine, subangular blocky structure breaking to moderate, very fine, granular; friable; slightly acid; gradual, smooth boundary.

A3—10 to 15 inches, very dark grayish-brown (10YR 3/2) light silty clay loam; faces of peds very dark brown (10YR 2/2); weak, fine, subangular blocky structure breaking to weak, very fine, subangular blocky and fine, granular; friable; medium acid; gradual, smooth boundary.

B1—15 to 20 inches, brown (10YR 4/3) light silty clay loam; weak to moderate, medium, subangular blocky structure; friable; patchy, dark-brown (10YR 3/3), organic coatings on peds; medium acid; gradual, smooth boundary.

B21—20 to 28 inches, brown (10YR 4/3) light to medium silty clay loam; weak to moderate, medium, subangular blocky structure; friable; patchy, dark-

brown (10YR 3/3), organic coatings on peds; slightly acid; gradual, smooth boundary.

B22—28 to 34 inches, brown (10YR 4/3) light to medium silty clay loam; weak to moderate, medium, subangular blocky structure; friable; slightly acid; gradual, smooth boundary.

B3—34 to 45 inches, brown (10YR 5/3) light silty clay loam; very few, fine, faint, light brownish-gray (2.5Y 6/2) mottles and few, fine, distinct, brown (7.5YR 5/4) mottles; weak, medium, subangular blocky structure; friable; slightly acid; diffuse, smooth boundary.

C—45 to 80 inches, yellowish-brown (10YR 5/4) silt loam; common, fine, distinct, olive-gray (5Y 5/2) mottles and common, fine, brown (7.5YR 4/4) mottles; massive; friable; band of soft black concretions 3 inches wide at a depth of 80 inches; slightly acid at a depth of 50 inches.

The surface layer is black, very dark brown, or very dark grayish-brown, friable light to medium silty clay loam 10 to 18 inches thick unless eroded. The subsoil ranges from 2 to 3 feet thick. It is dark-brown or brown light or medium silty clay loam in the supper part. Mottles of olive gray, light brownish gray, brown, grayish brown, and strong brown are at a depth below 30 inches. The lower part of the subsoil is dark-brown, brown, or yellowish-brown light or medium silty clay loam. The substratum is olive gray, grayish brown, or yellowish brown. These soils are generally medium acid to slightly acid in the subsoil and slightly acid to neutral in the substratum. Carbonates are lacking to a depth of 8 feet or more.

Marshall soils have a less developed, less clayey subsoil than Sharpsburg and Ladoga soils. They also have a thicker dark surface layer than Ladoga soils. Marshall soils are silty and lack the pebbles and sand-sized material that are in Shelby soils. They lack the very thick dark surface layer of Judson soils.

Marshall silty clay loam, 2 to 5 percent slopes (9B).—This soil is on convex ridgetops above more sloping Marshall soils. Areas are long and narrow or irregular in shape and range from 10 to 40 acres in size.

This soil has a profile similar to the one described as representative for the series, but the surface layer is 16 to 18 inches thick.

Except for farmsteads built on this land, and small pastures, all of this soil is cultivated. Runoff erodes the surface layer if vegetation is sparse. This soil is well suited to row crops if erosion is controlled. Some of this soil can be managed as individual fields, but most areas are managed with the more sloping Marshall soils downslope. (Capability unit IIe-1; woodland suitability group 2)

Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded (9C2).—This soil is on extended, narrow, convex ridgetops and on convex side slopes. It is downslope from less sloping Marshall soils and upslope from steeper ones. In many places it occurs as nearly continuous areas that band the ridgetops for considerable distances. Individual areas range from 5 to as much as 80 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping is about 50 acres in which the surface layer is very dark brown and about 14 to 18 inches thick.

Most of this soil is cultivated. It is well suited or moderately well suited to row crops if erosion is controlled. Runoff erodes the surface layer if vegetation is sparse. Nearly all of this soil is managed with other Marshall soils. (Capability unit IIIe-1; woodland suitability group 2)

Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded (9D2).—This soil occupies entire side slopes or at least the upper half of side slopes above Colo-Judson soils or Shelby soils. It is downslope from less sloping Marshall soils. Individual areas are 10 to 40 acres in size.

This soil has a profile similar to the one described as representative for the series, but the subsoil is 20 to 30 inches thick. A few grayish mottles are present below 24 inches in places. The surface layer is generally very dark grayish brown in color.

Included with this soil in mapping are a few areas of a soil that has slopes slightly greater than 14 percent.

Most of this soil is cultivated. Runoff erodes and gullies this soil if vegetation is sparse. Sidehill drainageways are common, but most are crossable. This soil is moderately well suited to row crops if erosion is controlled. Many areas of this soil are large and can be managed as separate fields. Some areas are managed with the less sloping Marshall soils upslope. (Capability unit IIIe-2; woodland suitability group 2)

Marshall silty clay loam, benches, 2 to 5 percent slopes (T9B).—This soil is on high stream benches in stream valleys in the northwestern part of the county. Some areas are surrounded by bottom-land soils, such as Colo, Kennebec, or Zook soils. Other areas are downslope from steeper Marshall soils and above the bottom-land soils. Individual areas range from 5 to 20 acres in size. The loess in which this soil formed is 10 to 20 feet thick and underlain by loamy sediments many feet thick.

Included with this soil in mapping are about 70 acres of a soil that has slopes of less than 2 percent. In these places, the surface layer is 16 to 18 inches thick.

Runoff erodes this soil if vegetation is sparse. In places additional runoff is received from soils upslope.

Much of this land is cultivated. It is well suited to row crops if erosion is controlled. Because of the irregular shape and position of some of this soil, erosion control measures are difficult to establish in places. Some of this soil is managed along with the bottom-land soils and other parts are managed with the more sloping Marshall soils upslope. (Capability unit IIe-1; woodland suitability group 2)

Montieth Series

The Montieth series consists of moderately deep to deep, light-colored, excessively drained, sandy soils on uplands. These soils are underlain by sandstone. They are on the lower part of convex side slopes or, in places, they occur as small knolls that crop out at the base of long slopes. Montieth soils are in the valleys of Brushy Creek and the Middle and South Raccoon Rivers and their tributaries. Individual areas range from 5 to about 40 acres or more in size. Slopes range from 9 to 30 percent.

These soils formed in material weathered from sandstone that is 10 to more than 40 feet thick. Below the sandstone is clayey shale or limestone bedrock. The native vegetation was grasses and trees.

In a representative profile, the surface layer is very dark grayish-brown loamy sand about 7 inches thick. Below this is a thin subsurface layer of brown to yellowish-brown, very friable sand. The subsoil consists of thin

bands of brown and reddish-yellow, friable sandy loam separated by layers of light yellowish-brown and light-gray, loose sand. Moderately cemented sandstone is at a depth of about 34 inches.

Montieth soils have low to very low available water capacity. They are rapidly or very rapidly permeable above the cemented sandstone. The water table is very deep. The surface layer is slightly acid to medium acid unless limed. Eroded areas are more acid. These soils are very low in available nitrogen, available phosphorus, and available potassium.

The surface layer is subject to soil blowing or erosion by runoff if vegetation is sparse. Severe droughtiness and lack of fertility limit crop growth. Nearly all of these soils are in pasture.

Some of the less sloping Montieth soils are cultivated along with the surrounding soils. Most areas are managed with the steep Gara soils upslope.

Representative profile of Montieth loamy sand, 14 to 18 percent slopes, 340 feet north and 360 feet east of the southwest corner of SE¼ sec. 19, T. 79 N., R. 31 W., on a west-facing, convex side slope of about 15 percent:

A1—0 to 7 inches, very dark grayish-brown (10YR 3/2) medium loamy sand, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; very friable; common pebbles; few rocks; slightly acid; clear, irregular boundary.

A2—7 to 12 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) medium sand; weak, medium, subangular blocky structure; very friable; streaks of very dark grayish brown (10YR 3/2); common pebbles; few rocks; medium acid; clear, wavy boundary.

Bt—12 to 17 inches, brown (7.5YR 4/4) light medium sandy loam; weak, medium, subangular blocky structure; very friable; thin, discontinuous clay films; strongly acid; clear, wavy boundary.

A'2—17 to 23 inches, light yellowish-brown (10YR 6/4) medium sand; single grain or loose; very friable; few to common roots; very strongly acid; clear, wavy boundary.

B't—23 to 27 inches, reddish-yellow (7.5YR 6/6) light medium sandy loam; weak, medium, subangular blocky structure; very friable; thin, discontinuous, reddish-brown (5YR 4/4) clay films; very strongly acid; clear, smooth boundary.

A'2—27 to 30 inches, light-gray (10YR 7/2) to very pale brown (10YR 7/3) medium sand; single grain; loose; few bands of strong brown (7.5YR 5/8); very strongly acid; clear, wavy boundary.

B't—30 to 34 inches, reddish-yellow (7.5YR 6/6) medium and fine sand; some horizontal cleavage; very friable; very thin bands of light gray (10YR 7/2); weak cementation of horizon; very strongly acid; clear, wavy boundary.

R—34 to 50 inches, light-gray (10YR 7/2) and light yellowish-brown (10YR 6/4) moderately cemented sandstone; thin bands of reddish yellow (7.5YR 6/6); very strongly acid.

The surface layer is very dark brown, very dark gray, or very dark grayish-brown loamy sand or sandy loam about 6 to 10 inches thick unless eroded. The subsurface layer is grayish-brown, brown, or yellowish-brown loamy sand or sand 2 to 6 inches thick. The subsoil consists of thin bands of brown, strong-brown, or reddish-yellow sandy loam interspaced with brown, light-yellowish brown, light-gray, or very pale brown sand. The sandstone is weakly to moderately cemented. Depth to the sandstone ranges from 24 to 40 inches. The subsoil and substratum are strongly or very strongly acid.

These soils differ from Hesch and Dickinson soils in that they have less clay in the solum, have cemented sandstone at a depth of about 3 feet, and have a subsoil and substratum consisting of thin, discontinuous bands of sandy loam and sand. Hesch soils formed in material weathered from sandstone but Dickinson soils did not, and the sand particles are predominantly fine in Dickinson soils.

Montieth loamy sand, 9 to 14 percent slopes (415D).—This soil is on the lower part of convex side slopes below Sharpsburg and Ladoga soils and, in places, below Shelby or Gara soils. In places areas are upslope from Gosport soils or soils on first bottoms. Individual areas range from 5 to 20 acres in size. This soil has a profile similar to the one described as representative for the series, but some areas have a sandy loam surface layer.

Included with this soil in mapping are places where the brownish subsoil is exposed on the surface. These are indicated on the map by a symbol for a severely eroded spot. Also included are a few areas that have a thicker sandy loam subsoil and some areas that have cemented sandstone or flags of ironstone outcropping. Also included are about 120 acres of Montieth loamy sand that has slopes of 5 to 9 percent.

This soil is subject to erosion by runoff and to soil blowing if the surface layer is barren or vegetation is sparse. Droughtiness, runoff, and low fertility limit the use of this soil.

Most areas are in pasture and are suited to this use. A few small areas surrounded by Gara soils are cultivated infrequently. All areas of this soil are managed along with the Gara or Hesch soils upslope or the steeper Montieth soils downslope. (Capability unit VIs-1; woodland suitability group 1)

Montieth loamy sand, 14 to 18 percent slopes (415E).—This soil is on the lower part of convex side slopes downslope from Shelby and Gara soils. Areas are commonly 200 to 400 feet wide and band the lower hillsides for ⅛ to ⅓ of a mile. The steeper Montieth soils and those on bottom lands are at lower elevations. Individual areas are 5 to 30 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping in places are some soils formed in glacial till or shale. Also included are areas that have cemented sandstone and numerous fragments of ironstone outcropping. About 160 acres are severely eroded. These places are indicated on the soil map by a symbol for a severely eroded soil.

This soil is subject to erosion by runoff and to soil blowing if vegetation is sparse. It is droughty and low in fertility.

This soil is mostly in pasture, but it has limited suitability for this use. A few areas that are partly wooded are left idle or pastured occasionally. These areas are suited to wildlife habitat. Some areas are large and can be managed as separate fields. Most are managed along with other Montieth soils or Shelby and Gara soils upslope. (Capability unit VIIs-1; woodland suitability group 1)

Montieth loamy sand, 18 to 30 percent slopes (415F).—This soil is on the lower part of convex side slopes. Areas are about 200 to 400 feet wide and band the lower hillsides for one-half mile or more. This soil is downslope from Shelby and Gara soils and upslope from soils on bottom lands. Individual areas are about 10 to 40 acres in size.

This soil has a profile similar to the one described as representative for the series, but cemented sandstone is generally at a depth between 24 and 30 inches.

Included with this soil in mapping are some outcroppings of cemented sandstone and flags of ironstone. Also included are some soils that have a loam surface layer and a thicker sandy loam subsoil. Small spots of shale or silty material are also included, as well as about 500 acres that slope up to 40 percent. Also included are areas where the brownish subsoil is exposed on the surface. These are indicated on the map by a symbol for a severely eroded spot.

Erosion and soil blowing, droughtiness, and low fertility limit the use of this soil.

This soil is suited to limited pasture. Partly timbered areas can be managed as woodland. Other areas have potential for wildlife habitat or for recreational uses (fig. 7). In some places farm equipment cannot be used safely because of gullies, escarpmentlike areas, and general steepness and shape of slopes. Some of the soil is managed as separate fields. Most areas are managed with other Montieth soils or Gara and Shelby soils. (Capability unit VIIs-1; woodland suitability group 1)

Nevin Series

The Nevin series consists of deep, dark-colored, somewhat poorly drained, silty soils on low stream benches or second bottom lands. Individual areas range from 5 to about 20 acres in size. Slopes range from 0 to 2 percent.

Nevin soils formed in silty alluvium about 3 to 10 feet thick. Below this depth are stratified loamy and sandy materials many feet thick. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black light silty clay loam about 16 inches thick. The subsoil extends to a depth of 45 inches. The upper part of the subsoil is dark grayish-brown silty clay loam; the middle part is grayish brown silty clay loam that feels gritty;

Figure 7.—**Rock outcrop and sand pit in an area of Montieth loamy sand enhance the "badlands" flavor of this farm operated as a guest ranch for children.**

and the lower part is light olive-brown clay loam with yellowish-brown mottles. The substratum is light olive-gray, very friable sandy loam.

Nevin soils have high available water capacity and are moderately or moderately slowly permeable. They have a water table at a depth of 2 to 4 feet during parts of the year. The surface layer is medium acid unless limed. Nevin soils are medium to low in available nitrogen, medium in available phosphorus, and low to medium in available potassium. These are among the most desirable soils in the county for farming.

They are slightly wet during periods of high rainfall, but wetness generally does not limit crop growth. Some areas are artificially drained to improve timeliness of field operations. In most places they are not subject to flooding, but they are sometimes flooded by water from tributary streams. Areas near the base of upland slopes receive runoff and some sediments.

All of the large areas are cultivated. Most Nevin soils are managed along with the associated Ely, Colo, or Zook soils.

Representative profile of Nevin silty clay loam, 9 feet north and 405 feet west of the southeast corner of SW¼NE¼ sec. 11, T. 78 N., R. 30 W., on a second bottom land of 1 percent slope:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam; weak, fine and very fine, granular structure; friable; medium acid; clear, smooth boundary.

A12—7 to 16 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) when kneaded; moderate, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

B1—16 to 24 inches, dark grayish-brown (10YR 4/2) medium silty clay loam; faces of peds very dark grayish brown (10YR 3/2); moderate, fine and very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B21t—24 to 32 inches, dark grayish-brown (2.5Y 4/2) and grayish-brown (2.5Y 5/2) medium silty clay loam; common, fine, distinct, light olive-brown (2.5Y 5/4) mottles; weak, fine, prismatic structure breaking to moderate, fine and medium, subangular blocky; friable; thin discontinuous clay films; slightly acid; gradual, smooth boundary.

B22t—32 to 38 inches, grayish-brown (2.5Y 5/2) medium silty clay loam; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles and common, medium, faint, dark grayish-brown (2.5Y 4/2) mottles; weak, medium, prismatic structure breaking to moderate, coarse and medium, subangular blocky; firm; thin, nearly continuous clay films on vertical faces; neutral; gradual, smooth boundary.

B3t—38 to 45 inches, light olive-gray (5Y 6/2) medium clay loam; common, medium, prominent, yellowish-brown (10YR 5/8) mottles; weak, medium, prismatic structure breaking to weak, medium and coarse, subangular blocky; firm; thin, discontinuous clay films; very dark brown (10YR 2/2) fills in worm channels; neutral; clear, smooth boundary.

C—45 to 54 inches, light olive-gray (5Y 6/2) sandy loam; common, medium, prominent, yellowish-brown (10YR 5/8) mottles; massive; very friable; common black oxides; common roots and pores; neutral.

The surface layer is black, very dark brown, or very dark gray and is 14 to 20 inches thick. The subsoil is about 2 to 3 feet thick. The upper and middle parts of the subsoil are very dark grayish brown to brown in hues of 10YR or 2.5Y and are silty clay loam in texture. Clay content ranges from 32 to 36 percent and averages less than 35 percent. The middle part of the subsoil has enough sand to feel gritty. The sand content increases slightly in the lower part of the subsoil in places. Mottles of grayish brown, light olive brown, brown, or yellowish brown are in the subsoil. The substratum ranges from silty clay loam, clay loam, or loam to sandy loam in places and is similar in color to the lower part of the subsoil. Nevin soils are medium to slightly acid in the upper part of the subsoil. Most of the subsoil and the substratum are slightly acid to neutral.

Nevin soils are similar to the Ely soils, but they have a more developed subsoil and a thinner surface layer. Nevin soils have a browner subsoil than Colo soils and are not so poorly drained.

Nevin silty clay loam (0 to 2 percent slopes) (88).—This soil is on low stream benches below soils on uplands, such as Sharpsburg and Shelby soils. It is also downslope from Ely soils and at a higher elevation than Colo or Zook soils.

Some of this soil has a silty clay loam texture to a depth of 6 feet or more. Included with this soil in mapping are a few small areas in which the subsoil is clay loam.

Areas adjacent to upland slopes receive runoff water and sediment from the uplands unless protected.

Nearly all of this soil is cultivated. Areas not accessible to tillage equipment are used for pasture. This soil is well suited to row crops. Almost all of this soil is managed along with the associated soils, such as Ely, Colo, and Zook soils. (Capability unit I-1; woodland suitability group 6)

Nicollet Series

The Nicollet series consists of deep, dark-colored, somewhat poorly drained, loamy soils on uplands. They are on the intermediate level between Clarion soils on knolls and Webster soils in swales. All of these soils are in the northeastern part of the county. Individual areas are irregular in shape and range from 5 to about 40 acres in size. Slopes range from 1 to 3 percent.

Nicollet soils formed in loam glacial till about 20 feet or more thick. In most places there are several feet of silts underlain by a gray, clayey, buried soil and clay loam till to a depth of 50 feet or more. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black loam grading to very dark grayish-brown light clay loam. It is about 21 inches thick. The subsoil is dark grayish-brown and mottled brown and yellowish-brown, friable light clay loam to a depth of about 37 inches. Below this is the substratum of mottled, light brownish-gray to grayish-brown, friable loam. Small stones and pebbles are common in the profile.

Nicollet soils have high available water capacity and are moderately permeable. They have a water table at a depth of 2 to 4 feet during parts of the year. The surface layer is slightly acid but generally does not need liming. These soils are low to medium in available nitrogen and available potassium and very low to low in available phosphorus. Nicollet soils are among the most productive soils in this county.

These soils are slightly wet during periods of high rainfall, but wetness does not limit crop growth. Some areas are artificially drained to improve timeliness of field operations. Most of the water that falls on the surface is absorbed.

Most areas of these soils are cultivated. If plowed in the fall and left barren, the surface layer is susceptible to soil blowing. Most areas are so irregular in shape that

they are managed along with the associated Clarion, Webster, and Okoboji soils.

Representative profile of Nicollet loam, 1 to 3 percent slopes, 66 feet south and 417 feet west of the northeast corner of sec. 30, T. 81 N., R. 30 W., on a convex slope of 2 percent:

Ap—0 to 8 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam; cloddy breaking to weak, fine, subangular blocky and weak, fine, granular structure; friable; some pebbles; slightly acid; abrupt, smooth boundary.

A12—8 to 17 inches, black (10YR 2/1) to very dark brown (10YR 2/2) heavy loam; weak, medium, granular structure; friable; some pebbles; slightly acid; gradual, smooth boundary.

A3—17 to 21 inches, very dark grayish-brown (10YR 3/2) light clay loam; weak, very fine, subangular blocky structure; friable; nearly continuous very dark gray (10YR 3/1) coatings on peds; some pebbles; slightly acid; clear, smooth boundary.

B1—21 to 26 inches, dark grayish-brown (10YR 4/2) light clay loam; weak, very fine, subangular blocky structure; friable; common, very dark grayish-brown (10YR 3/2), organic coatings on peds; some pebbles; slightly acid; clear, smooth boundary.

B2—26 to 31 inches, dark grayish-brown (10YR 4/2) to brown (10YR 4/3) light clay loam; weak, medium to coarse, subangular blocky structure; friable; few, very dark gray (10YR 3/1), organic coatings on peds; some pebbles; neutral; clear, smooth boundary.

B3—31 to 37 inches, yellowish-brown (10YR 5/4) to brown (10YR 5/3) light clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; some pebbles; thin, discontinuous, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) fills in worm and root channels; neutral; gradual, smooth boundary.

C—37 to 51 inches, light brownish-gray (2.5Y 6/2) to grayish-brown (2.5Y 5/2) loam; many, coarse, distinct, yellowish-brown (10YR 5/6) mottles; massive; friable; few medium black oxides; common fine lime concretions; some pebbles; strongly effervescent; mildly alkaline.

The surface layer is 16 to 24 inches thick and is black, very dark brown, very dark gray, and very dark grayish brown. The surface layer is loam in the upper part and light clay loam in the lower part. The subsoil is about 12 to 20 inches thick and is dark grayish brown, brown, and yellowish brown. The substratum is grayish-brown, yellowish-brown, brown, or light olive-brown, friable loam. Mottles of brown to gray are in the lower part of the subsoil and in the substratum. These soils are slightly acid to neutral in the subsoil and mildly alkaline or moderately alkaline in the substratum. Carbonates are at a depth of 30 to 40 inches.

Nicollet soils have a thicker surface layer than the well-drained Clarion soils and they are mottled in the subsoil. They are not so gray in the subsoil as the poorly drained Webster soils. Nicollet soils are not underlain by sands and gravels as are Cylinder soils.

Nicollet loam, 1 to 3 percent slopes (55A).—This soil is on slightly convex areas that are between Clarion soils on knolls and Webster soils in swales. A few areas are in concave, lower positions between areas of undulating Clarion or Storden soils. Most areas are about 10 acres in size.

Included with this soil in mapping are about 120 acres of soil in Victory and Cass Townships that are underlain by firm clay loam till at a depth of about 3 feet. Also included are a few small areas of Webster soils that have a gray subsoil.

Most of the water that falls on the surface is absorbed. On long slopes slight erosion occurs in places. Soil blowing is more of a hazard if large tracts of land are plowed in fall. In years of above average rainfall, this soil is slightly wet in areas that border Webster soils. Some areas are artificially drained to improve timeliness of field operations.

Most of this soil is cultivated. It is well suited to row crops. (Capability unit I-1; woodland suitability group 6)

Nodaway Series

The Nodaway series consists of deep, moderately dark colored, moderately well drained, silty soils on bottom lands. These soils are parallel to present stream and river channels on first bottom lands in all parts of the county. Some areas are distinctly undulating and contain numerous old oxbows or noncrossable stream channels. Individual areas range from 10 to 40 acres in size. Slopes range from 0 to 2 percent.

These soils formed in 3 to 5 feet of stratified silty alluvium. Beneath this, the alluvium is loamy or sandy to a depth of 20 feet or more. The native vegetation was young trees, shrubs, and grasses.

In a representative profile, the surface layer is very dark grayish-brown to dark grayish-brown silt loam about 11 inches thick. Below the surface layer, to a depth of about 36 inches, is stratified, very dark grayish-brown and dark grayish-brown, friable silt loam. Below this is stratified, dark grayish-brown, friable sandy loam, loamy sand, and loam.

These soils have high available water capacity and are moderately permeable. They are subject to flooding and have a water table at a depth of 3 to 5 feet or below during parts of the year. The channeled Nodaway soils are frequently flooded. The surface layer is generally neutral to mildly alkaline and does not need liming. These soils are very low in available nitrogen, medium in available phosphorus, and low to medium in available potassium.

Most of the Nodaway soils have been cleared and are cultivated. Those areas that are channeled and flooded are in pasture or woodland. Some areas are large and can be managed as separate fields. Many of the Nodaway soils are managed along with the adjacent Colo and Zook soils.

Representative profile of Nodaway silt loam, 750 feet north and 100 feet east of the southwest corner of SE¼ sec. 12, T. 78 N., R. 30 W., on first bottom land of 1 percent slope:

Ap—0 to 11 inches, very dark grayish-brown (10YR 3/2) to dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) to pale brown (10YR 6/3) when dry; weak, very coarse, platy structure due to stratification; friable; neutral; abrupt, smooth boundary.

C1—11 to 36 inches, stratified very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) gritty silt loam, grayish brown (10YR 5/2) to pale brown (10YR 6/3) when dry; weak, very coarse, platy structure; friable; mildly alkaline; gradual, smooth boundary.

C2—36 to 60 inches, stratified dark grayish-brown (10YR 4/2) sandy loam, loamy sand, and loam; massive; friable; sandy loam at a depth of 35 to 43 inches, loamy sand strata at 43 to 50 inches, and loam at

50 to 60 inches; mildly alkaline; gradual, smooth boundary.

The surface layer is very dark grayish-brown or dark grayish-brown silt loam 1 to 16 inches thick. In cultivated areas the plow layer is darkened by organic matter in places. Immediately below the plow layer, the substratum is stratified, dark grayish-brown, grayish-brown, brown, and very dark grayish-brown, friable silt loam 3 to 5 feet thick. Stratified sandy and loamy materials are at a depth below 36 inches. The Nodaway soils are slightly acid to mildly alkaline throughout. Free lime is lacking at a depth of less than 40 inches.

Nodaway soils differ from Kennebec soils in that they are stratified and lighter colored. They are not so dark colored, clayey, or poorly drained as Colo and Zook soils. Nodaway soils are not so variable in sand, silt, and clay content as Alluvial land.

Nodaway silt loam (0 to 2 percent slopes) (220).—This soil is on first bottom lands that border stream and river channels. It is at a slightly higher elevation than the associated Colo and Zook soils. Most areas are about 20 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are areas of black to very dark brown silt loam stratified with thin layers of grayish-brown, very friable loamy sand. These soils are darker than the soil described as representative.

The surface layer absorbs moisture readily. It also dries out soon after rains except in low areas or channel swales. This soil blows readily if the surface layer is left barren of vegetation.

Nearly all of this soil is cleared of young trees or shrubs and is cultivated. It is well suited to row crops if occasional flooding is controlled. Cottonwood, elm, boxelder, and willow trees grow in timbered areas. A few of the small, inaccessible wooded areas make excellent habitat for wildlife. Large timbered areas are generally cleared and used for crops. (Capability unit I-3; woodland suitability group 8)

Nodaway silt loam, channeled (0 to 2 percent slopes) (C220).—This soil is on undulating first bottom lands that contain meandering river or stream channels and old oxbows. Most of these channels are noncrossable. This soil is adjacent to other Nodaway soils and, in places, to the Colo or Zook soils. Areas of this soil are generally narrow and less than 20 acres in size.

This soil has a dark grayish-brown to brown surface layer. Beneath the surface layer are several black or very dark brown layers interbedded with thin layers of brown or grayish brown. Strata of very friable loamy sand to loam are in many places.

This soil is subject to frequent flooding and siltation. Old oxbows hold water for long periods of time.

None of this soil is cultivated. It is in pasture or young woodland and pasture. Cleared or partly cleared areas are suited to pasture. Wooded areas make excellent habitat for wildlife. Occasionally timbered areas can be managed as woodland, but most trees are young and of the less desirable species. Areas that are cleared of trees, leveled, and protected from flooding can be used for row crops. (Capability unit Vw-1; woodland suitability group 8)

Okoboji Series

The Okoboji series consists of deep, dark-colored, very poorly drained, silty soils. They are in landlocked depressions on uplands in the northeastern part of Guthrie County. Individual areas range from 2 to 10 acres in size.

These soils formed in sediments derived from glacial till. The sediments consist of silty material 4 to 6 feet thick that is underlain by loamy sediments or loam glacial till about 20 feet thick. Beneath the loam till is generally a silt layer several feet thick; a buried, gray, clayey soil; and many more feet of clay loam till. The native vegetation was grasses and sedges tolerant to excessive wetness.

In a representative profile, the surface layer is black medium silty clay loam about 23 inches thick. Beneath this, the subsoil is black, very dark gray, and dark gray, firm heavy silty clay loam to a depth of about 41 inches. The substratum is mottled dark-gray and olive, firm medium to heavy silty clay loam.

These soils have high available water capacity. They are moderately slowly or slowly permeable. They have a high water table and are ponded for a period of time unless artificially drained. The surface layer is neutral to mildly alkaline and does not need additions of lime. These soils are medium to low in available nitrogen, low to very low in available phosphorus, and low to medium in available potassium.

These soils are very wet. The surface layer is easily puddled if worked when wet. Most of the Okoboji soils are artificially drained or partly drained and cultivated. A few areas remain in pasture.

All of the Okoboji soils are managed along with the associated Clarion, Harps, Nicollet, and Webster soils. A few undrained areas are excellent for wildlife habitat.

Representative profile of Okoboji silty clay loam, 800 feet south and 60 feet west of the northeast corner of sec. 1, T. 81 N., R. 30 W., in a depressional area of 0 percent slope:

Ap—0 to 6 inches, black (N 2/0) medium silty clay loam; cloddy breaking to weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A12—6 to 10 inches, black (N 2/0) medium silty clay loam; weak, fine and very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A13—10 to 17 inches, black (N 2/0) to very dark gray (10YR 3/1) medium silty clay loam; weak, fine, granular structure; friable; neutral; clear, smooth boundary.

A14—17 to 23 inches, black (10YR 2/1) to very dark gray (10YR 3/1) medium to heavy silty clay loam; weak, medium, subangular blocky structure; firm; common pores; neutral; gradual, smooth boundary.

B1g—23 to 33 inches, very dark gray (N 3/0) to black (10YR 2/1) heavy silty clay loam; moderate, fine, subangular blocky structure; firm; few pores, shiny pressure faces; neutral; gradual, smooth boundary.

B2g—33 to 41 inches, dark-gray (5Y 4/1) and very dark gray (10YR 3/1) heavy silty clay loam; few dark grayish-brown (2.5Y 4/2) mottles; moderate, fine, subangular blocky structure; firm; neutral; clear, smooth boundary.

Cg—41 to 60 inches, mottled, dark-gray (5Y 4/1) and olive (5Y 5/3) medium to heavy silty clay loam; few, fine, distinct, strong-brown (7.5YR 5/6) mottles; very weak, medium, subangular blocky structure to massive; firm; neutral; clear, smooth boundary.

The surface layer is black or very dark gray, friable light silty clay loam to firm heavy silty clay loam 18 to 24 inches thick. The upper part of the subsoil is black to dark-gray, firm heavy silty clay loam. Very dark gray colors extend to a depth of about 36 inches in places. Mottles of dark grayish brown, grayish brown, or light olive brown are in the subsoil. The substratum ranges from medium or heavy silty clay

loam to clay loam. The surface layer is slightly acid to mildly alkaline.

Okoboji soils differ from Zook and Colo soils mainly in that they are in upland depressions and are generally shallower to gleyed layers. They also have more clay in the subsoil than the Colo soils. They have a lower sand content than Webster soils.

Okoboji silty clay loam (0 to 2 percent slopes) (6).—This soil is in distinctly concave depressions on uplands. Individual areas are about 5 acres in size.

Included with this soil in mapping are a few soils that have a surface layer of mucky silt loam or silt loam. Also included are soils that have a loamy subsoil and a thinner dark surface layer than that described as representative. Included areas that are calcareous on the surface and throughout the profile are indicated on the soil map by a symbol for a spot of calcareous soil.

This soil is wet. It has a high water table, and after heavy rains water is ponded in the depressions (fig. 8). If this occurs early in the season, the soil is tilled and replanted. Even if it is artificially drained, tillage operations are delayed after heavy rains. The surface layer puddles easily if worked wet.

Most of this soil is artificially drained or partly drained and cultivated. It is moderately well suited to row crops if wetness is controlled. In some years water is ponded long enough to drown out crops. All of this soil is managed along with the adjacent Clarion, Harps, Nicollet, and Webster soils. (Capability unit IIIw-1; woodland suitability group 9)

Olmitz Series

The Olmitz series consists of deep, dark-colored, moderately well drained, loamy soils on uplands. These soils are on foot slopes and fans. The glacial till-derived Shelby and Gara soils are upslope. Areas are narrow in width and 5 to 40 acres in size. Slopes range from 2 to 9 percent.

Olmitz soils formed in local loamy alluvium washed from the adjacent hillsides. The loamy alluvium is 4 to 10 feet thick. Below this alluvium, glacial till or somewhat sandy stratified alluvium is in places. Native vegetation was prairie grasses.

In a representative profile, the surface layer is black and very dark gray loam and clay loam about 32 inches thick. It grades to dark brown in the lower part. The subsoil is brown, friable light clay loam that has darker organic coatings. Below a depth of about 51 inches, the substratum is brown, friable clay loam to loam.

Figure 8.—Ponded water on Okoboji silty clay loam after a heavy rain.

Olmitz soils have high available water capacity. They are moderately permeable. The water table is generally at a depth below 6 feet, but runoff and seepage water from soils upslope are hazards. The surface layer is slightly acid to medium acid unless limed. These soils are medium to low in available nitrogen, low in available phosphorus, and low to medium in available potassium.

Runoff from soils upslope causes rills or gullies in these soils if vegetation is sparse. Sediments eroded from soils upslope are deposited on Olmitz soils in places.

Some of these soils are cultivated and some are in pasture. They are suited to cultivation. The areas are not large enough to be managed as separate fields. If cultivated, these soils are generally managed along with the bottom-land soils, such as Colo or Zook soils.

Representative profile of Olmitz loam, 5 to 9 percent slopes, 780 feet south and 140 feet west of the northeast corner of lot 1, sec. 3, T. 78 N., R. 32 W., on a southwest-facing slope of 4 percent:

Ap—0 to 7 inches, black (10YR 2/1) to very dark gray (10YR 3/1) heavy loam, very dark gray (10YR 3/1) when kneaded; cloddy breaking to weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A12—7 to 14 inches, black (10YR 2/1) to very dark gray (10YR 3/1) light clay loam, very dark gray (10YR 3/1) when kneaded; moderate and fine, medium, granular structure; friable; medium acid; gradual, smooth boundary.

A13—14 to 22 inches, black (10YR 2/1) to very dark grayish-brown (10YR 3/2) light clay loam, same when kneaded; moderate, fine to medium, subangular blocky structure; friable; medium acid; gradual, smooth boundary.

A3—22 to 32 inches, dark-brown (10YR 3/3) light clay loam, faces of peds very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2), very dark grayish brown (10YR 3/2) when kneaded; weak to moderate, fine, subangular blocky structure; friable; medium acid; gradual, smooth boundary.

B2—32 to 41 inches, brown (10YR 4/3) light clay loam; weak to moderate, fine, subangular blocky structure; friable; common, very dark grayish-brown (10YR 3/2), organic coatings; slightly acid; gradual, smooth boundary.

B3—41 to 51 inches, brown (10YR 4/3) light clay loam; weak, fine, subangular blocky structure; friable; some dark-brown (10YR 3/3) organic coatings; neutral; gradual, smooth boundary.

C—51 to 60 inches, brown (10YR 4/3 to 10YR 5/3) light clay loam to loam; weak, fine, subangular blocky structure; friable; neutral.

The surface layer is black, very dark brown, very dark gray, and very dark grayish-brown loam to medium clay loam 24 to 36 inches thick. The subsoil is brown or dark-brown grading to brown or dark yellowish-brown, friable light to medium clay loam 16 to 24 inches thick. Beneath this, the substratum is brown, dark yellowish-brown, or yellowish-brown, friable clay loam to loam. These soils are medium acid to slightly acid in the upper part of the subsoil. The lower part of the subsoil and the substratum are slightly acid to neutral.

Olmitz soils have a loamy rather than a silty subsoil as do Judson soils. They are better drained and have a browner subsoil than Ely soils, and are loamy rather than silty. The subsoil is browner and higher in clay content than in the Spillville soils.

Olmitz loam, 2 to 5 percent slopes (273B).—This soil is on low foot slopes and alluvial fans. It is upslope from Colo, Zook, or Olmitz-Colo soils. It is downslope from Shelby soils and, in places, from Gara soils. Individual areas are less than 10 acres in size. This soil has a profile similar to the one described as representative for the series, but the surface layer is about 36 inches thick.

Included with this soil in mapping are a few areas that have a mottled subsoil.

Runoff from soils upslope erodes this soil and deposits new sediments on the surface layer.

This soil is well suited to row crops if runoff and erosion are controlled. Small areas associated with steep Shelby soils upslope are used for pasture. If cultivated, this soil is managed along with the Colo and Zook soils on bottom lands. (Capability unit IIe-3; woodland suitability group 3)

Olmitz loam, 5 to 9 percent slopes (273C).—This soil is on high concave foot slopes below Shelby soils but upslope from less sloping Olmitz, Colo, Zook, or Olmitz-Colo soils. A few areas are in steep, narrow upland drainageways. Individual areas are less than 10 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few soils that have a mottled subsoil and are more poorly drained. Also included are a few dark-colored soils that are silty rather than loamy.

Runoff erodes this soil if vegetation is sparse. Sidehill drainageways develop into gullies unless erosion is controlled. A few areas contain noncrossable drainageways.

Part of this soil is cultivated, but much remains in pasture. This soil is well suited or moderately well suited to row crops if erosion is controlled. Many small areas are managed as pasture along with the steep Shelby soils upslope. Cultivated areas are managed with less sloping Olmitz, Colo, Zook, or Olmitz-Colo soils on bottom lands. (Capability unit IIIe-3; woodland suitability group 3)

Olmitz-Colo complex, channeled, 2 to 7 percent slopes (201B).—This soil complex is in narrow upland drainageways. Several noncrossable stream channels or drainageways occur. These soils are downslope from Shelby, Gara, and Lindley soils. Individual areas occur as long, narrow strips bordered by steep upland soils. Some areas are as much as 40 acres in size.

This complex is made up of about 50 percent Olmitz soils and 30 percent Colo soils. The remaining 20 percent is Spillville soils. The Olmitz and Colo soils have profiles similar to those described as representative for their respective series. The Spillville soils are dark colored to a depth of about 40 inches or more.

Runoff water from the surrounding uplands drains onto this soil. Gullies and deep drainageways form unless runoff is controlled. After heavy rains, water overflows the drainageways in places and flooding occurs. The floodwaters deposit more recent sediments that are low in fertility.

All of this complex is suited to pasture. Areas of it are wooded with young trees and shrubs. In places, large farm ponds and erosion control structures are built. Some areas make excellent habitat for wildlife. (Capability unit Vw-1; woodland suitability group 3)

Salida Series

The Salida series consists of moderately dark or dark colored, excessively drained soils on uplands. They are mottled yellowish-brown, light brownish-gray, and throughout the soil. Salida soils are in the northeastern

part of the county. They are on convex upland knolls or rises. Individual areas are generally small but range from 5 to 10 acres in size. Slopes range from 7 to 14 percent.

Salida soils formed in coarse glacial debris. The sands and gravels are 4 to about 20 feet thick. Glacial till is generally below the sands and gravels. Native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown sandy loam about 11 inches thick. Gravel-size material occurs. Beneath this, the substratum is dark yellowish-brown and brown, loose gravelly loamy sand and loamy sand and gravel high in content of lime. The entire profile is mildly alkaline.

Salida soils have very low available water capacity. They are very rapidly permeable. The water table is at a depth below 6 feet and is generally at a considerable depth. The surface layer is generally mildly alkaline and contains abundant lime. These soils are very low to low in available nitrogen and phosphorus and low in available potassium.

These soils are extremely droughty. Most of the water that falls on the surface is absorbed. It rapidly drains through this soil and out of the plant root zone. Soil blowing is a hazard if vegetation is sparse.

Some of the small, less sloping areas of Salida soils are cultivated along with the associated soils. Large areas are managed as pasture. Gravel pits are in many places, but most of these are abandoned.

Representative profile of Salida sandy loam, 7 to 14 percent slopes, moderately eroded, 380 feet north and 70 feet east of the southwest corner of SE¼ sec. 15, T. 80 N., R. 30 W., on a convex, north-facing knoll of about 3 percent slope:

Ap—0 to 8 inches, very dark brown (10YR 2/2) sandy loam; cloddy breaking to weak, very fine, granular structure; very friable; some gravel; slightly effervescent; mildly alkaline; clear, smooth boundary.

A12—8 to 11 inches, very dark grayish-brown (10YR 3/2) gravelly heavy sandy loam; weak, fine, granular structure; very friable; slightly effervescent; mildly alkaline; clear, smooth boundary.

C1—11 to 36 inches, dark yellowish-brown (10YR 4/4) to brown (7.5YR 4/4) gravelly loamy sand; single grain; loose; pebbles up to 2 inches in diameter; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C2—36 to 60 inches, dark yellowish-brown (10YR 4/4) to brown (10YR 4/3) loamy sand and gravel; single grain; loose; pebbles up to 2 inches in diameter; strongly effervescent; mildly alkaline.

The surface layer is black, very dark brown, very dark gray, or very dark grayish-brown, very friable sandy loam, gravelly loam, or loamy sand 8 to 14 inches thick. Beneath this, the substratum is brown, dark yellowish-brown, or yellowish-brown, loose gravelly loamy sand, medium to coarse sand, or gravel. These soils are mildly alkaline and have carbonates in all layers, except that the surface layer is neutral in places.

Salida soils differ from Dickinson, Montieth, and Hesch soils in that they have carbonates throughout the profile and much gravel-size material in the substratum. Salida soils lack the loam subsoil of Wadena soils.

Salida sandy loam, 7 to 14 percent slopes, moderately eroded (73D2).—This soil is on convex knolls and rises on uplands in the northeastern part of the county. It is associated with the Wadena, Storden, and Clarion soils in places. Individual areas are less than 10 acres in size. In some places the surface layer is thinner than that described in the representative profile.

Included with this soil in mapping are about 180 acres of soil that has a sandy loam or loam subsoil in which the underlying gravel is at a depth of about 20 to 24 inches. These areas are on stream benches or escarpments bordering stream benches. Some of the escarpments are on short slopes of more than 14 percent.

This soil is extremely droughty. It is also low in fertility. Soil blowing is a hazard if vegetation is sparse.

This soil is suited to pasture. A few, small, less sloping areas are cultivated along with the adjacent soils. Areas that contain abandoned gravel pits are left idle. (Capability unit VIs-1; woodland suitability group 1)

Sharpsburg Series

The Sharpsburg series consists of deep, dark-colored, moderately well drained, silty soils on uplands. They are on convex ridgetops and the upper parts of side slopes. Slopes range from 0 to 18 percent. A few are on high stream benches where slopes range from 2 to 5 percent. Sharpsburg soils are generally south of a line passing through the towns of Bayard and Panora. Individual areas range from about 10 to 80 acres in size.

Sharpsburg soils formed in loess about 12 to 16 feet thick. The loess is only about 4 feet thick on the steeper side slopes. Below the loess is an old, buried, grayish or reddish, clayey soil 2 to 10 feet thick. Beneath the buried soil is 20 to more than 50 feet of clay loam glacial till. The loess on benches is underlain by an old, reddish or grayish soil formed in alluvium or stratified loamy alluvium that is many feet deep. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown silty clay loam about 13 inches thick. The subsoil extends to a depth of about 53 inches. It is brown, firm heavy silty clay loam in the upper part and mottled yellowish-brown, light-brownish gray, and strong-brown, friable medium to light silty clay loam in the lower part.

Sharpsburg soils have high available water capacity. They are moderately slowly permeable. The nearly level areas have a perched water table as high as 5 feet in places, but generally the water table corresponds to the thickness of the loess. The surface layer is slightly acid unless limed, but in places it is more acid. These soils are low to medium in available nitrogen and phosphorus and medium to high in available potassium.

The sloping soils erode if the surface is bare or if vegetation is sparse. Most of these soils are cultivated. Some small areas associated with Shelby or Shelby-Adair soils downslope are managed as pasture. The nearly level Sharpsburg soils are among the most desirable soils in the county for farming.

Representative profile of Sharpsburg silty clay loam, 2 to 5 percent slopes, 80 feet south and 480 feet east of the northwest corner of SW¼NE¼ of sec. 31, T. 78 N., R. 30 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) silty clay loam; cloddy breaking to weak, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A12—8 to 13 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) when kneaded; weak, fine, subangular blocky structure

breaking to moderate, fine, granular; friable; slightly acid; clear, smooth boundary.

B1—13 to 18 inches, brown (10YR 4/3) heavy silty clay loam; faces of peds very dark grayish brown (10YR 3/2); moderate, fine, subangular blocky structure; friable; medium acid; clear, smooth boundary.

B21t—18 to 23 inches, brown (10YR 4/3) heavy silty clay loam; moderate, fine, subangular blocky structure; firm; thin, discontinuous clay films; patchy very dark grayish-brown (10YR 3/2) organic coatings; medium acid; gradual, smooth boundary.

B22t—23 to 31 inches, brown (10YR 5/3) medium silty clay loam; moderate, fine and medium, subangular blocky structure; firm; thin, discontinuous clay films on vertical faces of peds; slightly acid; gradual, smooth boundary.

B23t—31 to 41 inches, yellowish-brown (10YR 5/4) and light brownish-gray (2.5Y 6/2) medium silty clay loam; common, fine, distinct, strong-brown (7.5Y 5/8) mottles; weak, medium, prismatic structure breaking to moderate, fine and medium, subangular blocky; friable; few, fine, black oxides; thin, discontinuous clay films; slightly acid; gradual, smooth boundary.

B31t—41 to 47 inches, mottled yellowish-brown (10YR 5/4), light brownish-gray (2.5Y 6/2), and strong-brown (7.5YR 5/8) light silty clay loam; weak, medium, prismatic structure breaking to weak, medium, subangular blocky; friable; few to common, fine, black oxides; few, thin, discontinuous clay films in pores and root channels; slightly acid; clear, smooth boundary.

B32—47 to 53 inches, mottled yellowish-brown (10YR 5/4), light brownish-gray (2.5Y 6/2), and strong-brown (7.5YR 5/8) light silty clay loam; very weak, coarse, prismatic structure; friable; few to common, fine, black oxides; neutral.

The surface layer is black, very dark brown, very dark gray, or very dark grayish brown, friable light to medium silty clay loam 10 to 18 inches thick. The subsoil is brown and dark yellowish-brown, firm heavy silty clay loam in the upper part. It is mottled yellowish-brown, olive-gray, grayish-brown, light brownish-gray, and strong-brown, friable light and medium silty clay loam in the lower part. Grayish mottles are evident at a depth below 30 inches. The subsoil is about 3½ feet thick in nearly level areas, but it is as thin as 2 feet thick in places in sloping areas. The substratum is friable silty clay loam to silt loam and is similar in color to the lower part of the subsoil. In places, however, it is grayish brown, light brownish gray, or olive gray at a depth below about 40 inches. These soils are medium acid to slightly acid in the upper part of the subsoil. The lower part of the subsoil and the substratum are slightly acid to neutral.

Sharpsburg soils have a thicker dark surface layer and are less acid in the subsoil than Ladoga or Clinton soils. They also lack the grayish subsurface layer and the silt coatings on peds. They are silty throughout the profile rather than loamy as are Shelby soils. Sharpsburg soils have a thinner dark surface layer, have more clay in the subsoil, and are more developed than Judson soils.

Sharpsburg silty clay loam, 0 to 2 percent slopes (370A).—This soil is on moderately wide, slightly convex divides or ridgetops. It borders Macksburg soils in places and is above more sloping Sharpsburg soils. Individual areas range from about 10 to 20 acres in size.

This soil has a surface layer of black or very dark brown, friable light silty clay loam about 12 to 18 inches thick. The subsoil extends to a depth of about 60 inches in places. Included with this soil in mapping are a few small areas of Macksburg soils.

There are no serious limitations to use of this soil for crops. All of it is cultivated, and it is well suited to row crops. Most areas of the soil are not large and are managed along with the associated Macksburg soils or the more sloping Sharpsburg soils. It is one of the most desirable soils in the county for farming. (Capability unit I-1; woodland suitability group 2)

Sharpsburg silty clay loam, 2 to 5 percent slopes (370B).—This soil is on convex ridgetops and the upper part of side slopes and head slopes. It is downslope from nearly level Sharpsburg and Macksburg soils and upslope from steeper Sharpsburg soils. Individual areas are often narrow and form a continuous band that extends for a mile or more. Individual areas range from 10 to about 80 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few areas on convex head slopes that have several crossable drainageways. Also included are Colo soils near or adjacent to the drainageways.

Runoff erodes this soil if vegetation is sparse. Most of the soil is cultivated and used for row crops. It is well suited to row crops if erosion is controlled. Some areas are large enough to be managed as separate fields. Other areas are managed along with the less sloping Sharpsburg or Macksburg soils upslope or the more sloping Sharpsburg soils downslope. (Capability unit IIe-1; woodland suitability group 2)

Sharpsburg silty clay loam, 5 to 9 percent slopes (370C).—This soil is commonly on narrow, extended, convex ridgetops. A few areas are on the upper parts of side slopes. It is upslope from steep Shelby, Adair, or Shelby-Adair soils. In places it is downslope from less sloping Sharpsburg soils. Individual areas are variable in size and range from 5 to 20 acres. This soil has a surface layer that is black to very dark brown and 12 to 16 inches thick.

Included with this soil in mapping are areas that have mottles and a grayer subsoil than is representative for the series.

Runoff erodes the surface layer if vegetation is sparse. Much of this soil is in pasture. It is well suited or moderately well suited to row crops if erosion is controlled. Much of this soil is associated with steep Shelby soils, and in these places it is managed as pasture. Areas associated with other Sharpsburg soils are cultivated. (Capability unit IIIe-1; woodland suitability group 2)

Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded (370C2).—This soil is on narrow, convex ridgetops and the upper parts of side slopes. It is in narrow areas that band the ridgetops and side slopes for considerable distances. It is downslope from less sloping Macksburg and Sharpsburg soils and upslope from steeper Sharpsburg, Clarinda, Lamoni, Adair, or Shelby-Adair soils. Individual areas range from 10 to 40 acres in size.

This soil has a profile similar to the one described as representative for the series, but the surface layer is somewhat thinner. In a few places the brownish subsoil is exposed.

Included in mapping are some soils on side slopes that are mottled at a shallower depth and have a grayer subsoil. If Clarinda soils are downslope, some Clearfield soils are also included.

Runoff erodes this soil if vegetation is sparse. Narrow areas immediately above Clarinda or Lamoni soils are somewhat seepy in periods of high rainfall.

This soil is well suited or moderately well suited to row crops (fig. 9) if erosion is controlled. Most of this soil is managed as individual fields or along with the less sloping Sharpsburg soils upslope. (Capability unit IIIe-1; woodland suitability group 2)

Sharpsburg silty clay loam, 9 to 14 percent slopes (370D).—This soil is on the upper parts of convex side slopes above steep Shelby soils. A few areas are on very narrow, extended ridgetops. Individual areas range from 5 to 20 acres in size.

This soil has a surface layer of black or very dark brown silty clay loam about 10 to 16 inches thick. The subsoil is nearly 36 inches thick, but it is thinner than is representative for the series.

Included with this soil in mapping are a few small areas of soils that have a grayish or reddish, clayey subsoil. These are indicated on the map by a symbol for a red or gray clayey spot.

Runoff erodes this soil if vegetation is sparse. Most of the soil is in pasture and is managed along with the steeper Shelby soils downslope. Large areas are moderately well suited to row crops if erosion is controlled. This soil is less suited to cultivation than some Sharpsburg soils, because the associated soils are steep and many individual areas are small. (Capability unit IIIe-2; woodland suitability group 2)

Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded (370D2).—This soil bands the upper parts of convex side slopes and head slopes. It is downslope from less sloping Sharpsburg soils and upslope from Shelby, Adair, Lamoni, or Shelby-Adair soils. Individual areas are 10 to about 80 acres in size.

This soil has a slightly thinner surface layer than the one described in the representative profile. The subsoil is about 3 feet thick. The brownish subsoil is exposed on the surface in places, and these areas are indicated on the map by a symbol for severely eroded spots.

Included with this soil in mapping are a few small areas of soils that have a grayish or reddish, clayey subsoil. These places are indicated on the map by a symbol for red or gray clayey spots.

Erosion is a hazard if vegetation is sparse. Sidehill drainageways develop into gullies unless runoff is controlled. Narrow areas immediately above Adair, Lamoni, or Shelby-Adair soils are somewhat seepy in periods of high rainfall.

Nearly all of this soil is cultivated. It is moderately well suited to row crops if erosion is controlled. Large areas of this soil are managed as individual fields. Some areas are managed along with the associated less sloping Sharpsburg soils upslope. (Capability unit IIIe-2; woodland suitability group 2)

Sharpsburg silty clay loam, 14 to 18 percent slopes, moderately eroded (370E2).—This soil is on the upper part of convex side slopes. It is above Shelby soils in most places and downslope from less sloping Sharpsburg soils. Individual areas are about 5 to 20 acres in size. This soil has a profile similar to the one described as representative for the series, but the subsoil is about 30 to 36 inches thick and contains slightly less clay.

Included with this soil in mapping are a few small areas of soils that have a clay loam till subsoil. These are indicated on the map by a symbol for glacial till spots.

Runoff erodes this soil if the vegetation is sparse. It is better suited to pasture than to row crops. It is poorly suited to row crops, even if erosion is controlled. Most areas are small in size and are cultivated and managed with less sloping Sharpsburg soils. (Capability unit IVe-2; woodland suitability group 2)

Sharpsburg silty clay loam, benches, 2 to 5 percent slopes (T370B).—This soil is on high, convex stream benches. It is downslope from upland loess and till-derived soils and above Colo or Zook soils. It is at higher elevations than Nevin soils. Individual areas are 10 to 20 acres in size. This soil has a profile similar to the one described as representative for the series, but the loess is underlain by stratified loamy alluvium. In the upper part of the alluvium, there is an old, buried, red and gray, clayey soil in places.

Included with this soil in mapping is 180 acres of a nearly level Sharpsburg soil on benches.

Runoff from soils upslope drains across this soil in places. Erosion is a hazard if vegetation is sparse. Runoff from soils upslope should be diverted.

Most of this soil is cultivated. It is well suited to row crops if erosion is controlled. Small areas are managed along with the surrounding Judson or Ely soils or bottomland soils, such as the Colo soils. (Capability unit IIe-1; woodland suitability group 2)

Shelby Series

The Shelby series consists of deep, dark-colored, moderately well drained, loamy soils on uplands. Small stones and pebbles are throughout the profile. These soils are on convex side slopes in all but the northeastern part of the county. Individual areas range from 10 to more than 80 acres in size. Slopes range from 2 to 25 percent.

These soils formed in clay loam glacial till that is 20 to more than 50 feet thick in places. In steep areas on side slopes in the central and southeastern part of the county the till is thinner and is underlain by many feet of sandstone. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown and dark brown loam and light clay loam about 14 inches thick. The subsoil is brown, firm light to heavy clay loam about 16 inches thick. Below this, the substratum is dark yellowish-brown to yellowish-brown, firm medium clay loam mottled with olive gray. It is high in content of lime.

These soils have high available water capacity and are moderately slowly permeable. A water table is at a depth of more than 5 feet. The surface layer is slightly acid unless limed, but some areas are more acid. These soils are low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Erosion from runoff is a hazard. Sidehill drainageways are common and develop into gullies unless protected. The Shelby soils are mostly in pasture. The less sloping areas are cultivated.

Representative profile of Shelby loam, 14 to 18 percent slopes, moderately eroded, 360 feet south and 170 feet west of the northeast corner of the SE¼ sec. 18, T. 78 N., R. 32 W., on a slope of 14 percent:

Ap—0 to 8 inches, very dark brown (10YR 2/2) heavy loam; cloddy breaking to weak, fine and very fine,

Figure 9.—**Terraces on Sharpsburg silty clay loam are used to control erosion.**

granular structure; friable; few pebbles; slightly acid; abrupt, smooth boundary.

AB—8 to 14 inches, dark-brown (10YR 3/3) light clay loam, very dark grayish brown (10YR 3/2) when kneaded; faces of peds very dark grayish brown (10YR 3/2); moderate, fine, subangular blocky structure; friable; few pebbles; slightly acid; gradual, smooth boundary.

B21t—14 to 21 inches, brown (10YR 4/3) light to medium clay loam; moderate, medium, subangular blocky structure; firm; thin discontinuous clay films; few, fine, faint, black oxides; few pebbles; slightly acid; diffuse, smooth boundary.

B22t—21 to 30 inches, brown (10YR 4/3 to 5/3) medium to heavy clay loam; moderate, coarse, subangular blocky structure; firm; thin, continuous clay films; common, fine, soft, red and black oxides; some pebbles; slightly acid; gradual, smooth boundary.

C1—30 to 47 inches, dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/4) medium clay loam; weak, coarse, subangular blocky structure; firm; common, medium and coarse, lime concretions; common, fine, soft, black and yellowish-red oxides; some pebbles; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C2—47 to 60 inches, dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/4) medium clay loam; common, medium, distinct, olive-gray (5Y 5/2) mottles; massive; firm; common, fine, lime concretions; common, medium, soft, yellowish-red and black oxides; some pebbles; strongly effervescent; mildly alkaline.

The surface layer is black, very dark brown, very dark gray, or very dark grayish-brown, friable loam. Most of these soils have a thin transitional layer between the surface layer and the subsoil that is very dark grayish-brown or dark-brown, friable light to medium clay loam. The combined thickness of the surface layer and transitional layer ranges from 10 to 18 inches. The subsoil is brown, dark yellowish-brown, and yellowish-brown, firm light to medium clay loam. Some thin layers are heavy clay loam. Mottles of grayish brown, olive brown, or strong brown are in the lower part of the subsoil in places and increase in size and abundance as depth increases. The substratum is light or medium clay loam. These soils are medium acid to slightly acid in the upper part of the subsoil. Below a depth of 2 or 3 feet they are

slightly acid to mildly alkaline in reaction. Carbonates are typically at a depth between 30 and 48 inches.

Shelby soils have a thicker dark surface layer and are typically less acid than Gara, Lester, or Lindley soils, and they lack a grayish subsurface layer. They have a thinner dark surface layer and a more developed subsoil than Olmitz soils. Shelby soils are finer textured, firmer, and have a more developed subsoil than Clarion soils.

Shelby loam, 2 to 5 percent slopes (24B).—This soil is on long, convex slopes in Victory, Cass, and Jackson Townships north of the Raccoon River. This soil is upslope from Nicollet and Webster soils. Individual areas range from 5 to 20 acres in size.

This soil has a profile similar to the one described as representative for the series, but it has about 30 inches of friable loam over a clay loam till. The surface layer and the upper part of the subsoil are friable loam. The lower part of the subsoil and the substratum are firm clay loam.

Runoff erodes the surface layer if vegetation is sparse. All of this soil is cultivated. It is well suited to row crops if erosion is controlled. Although some areas are fairly large in size, most of this soil is managed along with the adjacent soils. (Capability unit IIe-2; woodland suitability group 3)

Shelby loam, 5 to 9 percent slopes, moderately eroded (24C2).—This soil is on convex side slopes. Individual areas range from 5 to 20 acres in size.

Most of this soil that is north of the Raccoon River has about 18 to 30 inches of loam underlain by clay loam till. The upper part of the profile is friable loam. Some of the subsoil and all of the substratum is firm clay loam. In other parts of the county, the profile of this soil is similar to the one described as representative for the series, but it tends to be leached more deeply.

Erosion is a hazard if vegetation is sparse. Much of this soil is cultivated. It is well suited or moderately well suited to row crops if erosion is controlled. Areas in the southern or southwestern parts of the county are generally in pasture. These areas are small and are less accessible to tillage equipment or are associated with steeper soils. Cultivated areas are managed along with the associated soils. (Capability unit IIIe-3; woodland suitability group 3)

Shelby loam, 9 to 14 percent slopes, moderately eroded (24D2).—This soil is on the lower part of convex side slopes in the southern and southeastern part of the county. A few areas are on uplands adjacent to, but north of, the Raccoon River. It is typically downslope from Adair, Lamoni, and Sharpsburg soils. Individual areas are 10 to 40 acres in size.

This soil has a profile similar to the one described as representative for the series, but the subsoil is about 24 inches thick and no carbonates are at a depth of less than 36 inches. At the base of some long slopes, the soil has a thicker surface layer and a friable subsoil.

Included with this soil in mapping are about 250 acres of Olmitz soils that have a thicker dark surface layer. Also included are small areas that have a clayey subsoil. Also included are areas north of the Raccoon River that have 18 to 24 inches of loam underlain by firm clay loam.

Runoff erodes this soil if vegetation is sparse. Sidehill drainageways are common and develop into gullies if runoff is not controlled. Stock ponds or erosion control structures are built in this soil or in the narrow upland drainageways downslope and adjacent to this soil.

Most of this soil is cultivated or has been in the past. It is moderately well suited to row crops if erosion is controlled. It is generally managed along with the Sharpsburg soils upslope. (Capability unit IIIe-4; woodland suitability group 3)

Shelby loam, 14 to 18 percent slopes, moderately eroded (24E2).—This soil bands the low part of convex side slopes below Sharpsburg, Adair, or Lamoni soils. It is upslope from Olmitz-Colo soils or, in places, Colo-Judson soils in drainageways. Individual areas range from about 10 to 80 acres or more in size. This soil has the profile described as representative for the series.

Some areas have a surface layer of black or very dark gray, friable loam 10 to 16 inches thick. Included with this soil in mapping are a few small areas north of the Raccoon River that have 18 to 24 inches of loam underlain by firm clay loam.

Runoff erodes this soil if vegetation is sparse. Sidehill drainageways are common and gullies are in places. Stock ponds or erosion control structures are built in this soil or in narrow upland drainageways that are downslope and adjacent to this soil. Young trees and shrubs encroach on pastures unless controlled.

Some of this soil that is associated with Sharpsburg soils is cultivated. The soil associated with large areas of Adair and Lamoni soils or with steeper Shelby soils is in pasture. This soil is poorly suited to pasture and row crops, even if erosion is controlled. (Capability unit IVe-2; woodland suitability group 3)

Shelby loam, 18 to 25 percent slopes, moderately eroded (24F2).—This soil is on convex side slopes that are partly dissected by sidehill drainageways. It occupies the entire side slope or the lower two-thirds of the side slope below Sharpsburg soils. It is generally upslope from Olmitz-Colo soils in drainageways. Individual areas are variable in size but range from 10 to 40 acres.

This soil has a profile similar to the one described as representative for the series, but the subsoil has olive-gray or grayish-brown mottles at a depth of 24 inches and below in places.

Included with this soil in mapping are some spots that have a reddish or grayish, clayey subsoil. These places are indicated on the soil map by a symbol for a red or gray clayey spot.

Runoff erodes the surface layer, and gullies form if vegetation is sparse. Stock ponds and erosion control structures are built in this soil or in the upland drainageways that are downslope and adjacent to it. Some gullies need to be shaped before tillage equipment can be used.

All of this soil is in pasture. It is suited to pasture. Small areas are managed along with the Shelby or other soils upslope. (Capability unit VIe-2; woodland suitability group 4 or 5)

Shelby soils, 14 to 18 percent slopes, severely eroded (24E3).—These soils are on convex side slopes that are partly dissected by sidehill drainageways. They are adjacent to other Shelby soils. They are most common in the southern and southeastern part of the county. Areas are about 5 to 15 acres in size.

These soils have a profile similar to that described as representative for the series, but the surface layer is thinner and ranges from brown, dark-brown, or dark grayish-brown loam to clay loam. Near sidehill drainageways, the surface layer is thicker and darker.

Tilth is generally poor. Rainfall is not absorbed readily, and runoff erodes and gullies the soil if vegetation is sparse. Some gullies need to be shaped before tillage equipment can be used.

Most of these soils have been cultivated in the past. They are suited to pasture. Most areas are small and are managed along with the adjacent Shelby soils. (Capability unit VIe-2; woodland suitability group 3)

Shelby soils, 18 to 25 percent slopes, severely eroded (24F3).—These soils are on convex side slopes dissected by sidehill drainageways and gullies in places. Most areas are downslope from Sharpsburg soils but adjacent to other Shelby soils. Most areas are about 5 to 20 acres in size.

These soils have a profile similar to that described as representative for the series, but the surface layer is thinner brown, dark-brown, or dark grayish-brown loam or clay loam. In a few places, carbonates are at a depth of about 2 feet.

Included in mapping near the upper boundary of these soils are some small areas that have a reddish or grayish, clayey subsoil. These places are indicated on the soil map by a symbol for red or gray clayey spots.

Most of these soils are in pasture. Vegetation is sparse in places, and the surface layer is eroded. Gullies need to be shaped before tillage equipment can be used. These soils are generally managed along with the adjacent less eroded Shelby soils. Small areas can be planted to trees and managed as woodland. (Capability unit VIe-2; woodland suitability group 4 or 5)

Shelby-Adair complex, 9 to 14 percent slopes, moderately eroded (93D2).—This soil complex is on irregular, convex side slopes that are partly dissected by sidehill drainageways. The Adair soils in the complex are near the upper boundary of the complex, and the Shelby soils are on the lower part of side slopes. This complex is downslope from Sharpsburg and, in places, Ladoga soils and upslope from Olmitz-Colo complex, channeled, or Colo-Judson complex in drainageways. Areas range from 10 to 40 acres in size.

This complex consists of about 50 to 75 percent Shelby soils and 25 to 50 percent Adair soils. Shelby and Adair soils have profiles similar to the ones described as representative for their respective series.

Included in mapping are a few areas of soils that have a grayish, clayey subsoil rather than a reddish clayey subsoil as do the Adair soils. Also included are areas of soils downslope from Ladoga soils that are slightly more acid and have a somewhat thinner surface layer.

These soils erode if vegetation is sparse. Rills and gullies form in sidehill drainageways unless runoff is controlled. Some areas are cultivated, but most areas are in pasture. These soils are poorly suited to row crops. If they are used for row crops, erosion must be controlled. The Adair soils are difficult to till if eroded. In places, farm ponds or erosion control structures are built in this complex or in the narrow drainageways adjacent to but downslope from it. Most of this complex is managed as separate fields or along with the soils upslope. (Capability unit IVe-1; woodland suitability group 3)

Shelby-Adair complex, 9 to 14 percent slopes, severely eroded (93D3).—This soil complex is on irregular, convex side slopes. Most of it is dissected by some sidehill drainageways and gullies. It is adjacent to other Shelby-Adair soils or Shelby soils downslope. It is below Sharpsburg soils. The Adair soils in the complex are near the upper boundary of the complex and the Shelby soils are downslope. Areas range from 5 to as much as 20 acres in size.

This complex is about 50 to 75 percent Shelby soils and 25 to 50 percent Adair soils. The Shelby and Adair soils in this complex have a thinner surface layer than that described as representative for their respective series. The Adair part of the complex is generally more eroded than the Shelby part, and the brown to reddish-brown subsoil is exposed on the surface in places.

Included in mapping are a few places where a gray clayey soil occurs rather than the reddish Adair soils. These are indicated on the map by a symbol for a gray clayey spot.

Runoff erodes this complex, and sidehill drainageways develop into gullies unless erosion is controlled. If tillage equipment is to be used, some noncrossable gullies need to be shaped and young trees and shrubs along drainageways need to be cleared from some areas. The eroded Adair soils are difficult to till. Farm ponds or erosion control structures are built in this complex or in the narrow drainageways downslope.

All but some very small areas of this complex are in pasture. This complex is suited to pasture. Most of this complex is managed along with other Shelby-Adair soils or with Shelby soils. (Capability unit VIe-1; woodland suitability group 3)

Shelby-Adair complex, 14 to 18 percent slopes, moderately eroded (93E2).—This soil complex occupies the entire lower part of irregular, convex side slopes. Sidehill drainageways and some gullies are common. It is downslope from Sharpsburg and occasionally Ladoga soils and above Olmitz-Colo complex, channeled, or, in places, Colo-Judson complex in narrow drainageways. Individual areas range from 10 to 80 acres in size.

This complex has about 60 to 80 percent Shelby soils and about 20 to 40 percent Adair soils. The Shelby soils are downslope along the lower boundary of the complex. The Adair soils are along the upper boundary of the complex. The Shelby and Adair soils in this complex have profiles similar to the ones described as representative for their respective series.

Included with this complex in mapping are a few small areas that have a grayish, clayey subsoil instead of a reddish, clayey subsoil as does the Adair series. These are indicated on the soil map by a symbol for gray clayey spots. Also included are a few areas downslope from Ladoga soils where this complex is generally more acid and has a thinner surface layer.

Erosion is a hazard if vegetation is sparse. Rilling and gullying occur unless runoff is controlled. In places noncrossable gullies need to be shaped and young trees or shrubs need to be cleared from drainageways if tillage equipment is used. Farm ponds or erosion control structures are built in this soil complex or in the narrow drainageways that are downslope. Most of this complex is in pasture and it is suited to this use. Most areas are large and can be managed as separate fields. (Capability unit VIe-1; woodland suitability group 3)

Shelby-Adair complex, 14 to 18 percent slopes, severely eroded (93E3).—This complex is on irregular, convex side slopes. Some sidehill drainageways and gullies

dissect this complex. It is generally adjacent to other, less eroded Shelby-Adair soils. It is downslope from Sharpsburg and, in places, Ladoga soils. It is upslope from Olmitz-Colo complex, channeled, and, in places, Colo-Judson complex. Areas range from 5 to 20 acres in size.

This complex has about 60 to 80 percent Shelby soils and 20 to 40 percent Adair soils. The Shelby and Adair soils have thinner surface layers than described as representative for each series. Included are a few areas with grayish clayey subsoils. These are shown on the soil map by a symbol for a gray clayey spot. The Adair soils occur near the upper boundary of this complex and Shelby soils are downslope. In the Adair soils, which are the most severely eroded, the brown to reddish-brown subsoil is exposed on the surface.

Runoff erodes this soil if vegetation is sparse. Noncrossable drainageways or gullies need to be shaped and young trees and shrubs need to be removed before tillage equipment can be used. These soils are suited to pasture and mostly used as such. Some areas are planted to trees and managed as woodland. Most of this soil complex is managed along with the adjacent less eroded Shelby-Adair or Shelby soils. (Capability unit VIIe-1; woodland suitability group 3)

Spillville Series

The Spillville series consists of deep, dark-colored, moderately well drained and somewhat poorly drained, loamy soils on bottom lands. They are on first bottom lands and low foot slopes. These soils are in all parts of the county, but the total acreage is small. Individual areas range from 5 to 20 acres in size. Slopes range from 1 to 3 percent.

Spillville soils formed in about 3½ to 5 feet of loamy alluvium. Beneath this, in bottom-land positions, is 10 to more than 20 feet of stratified loamy to sandy alluvium. In foot slope positions, loam glacial till is generally at a depth of about 10 feet. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black and very dark brown loam about 40 inches thick. Below this, the substratum, to a depth of about 52 inches, is very dark grayish-brown and dark grayish-brown, friable loam to fine sandy loam. The substratum grades to dark grayish-brown to grayish-brown, very friable fine sandy loam as depth increases. A few brown and gray mottles are below a depth of 40 inches.

These soils have high available water capacity. They are moderately permeable. The water table is generally at a depth of 5 feet and below, but during parts of the year it is at a depth as shallow as 3 feet in places. The surface layer is neutral, but some areas are more acid unless limed. Spillville soils are medium to high in available nitrogen and medium in available phosphorus and available potassium.

In places they receive runoff water from soils upslope. The more level areas on bottom lands are occasionally flooded during periods of high rainfall. The surface layer dries out quickly and can be worked fairly soon after rains.

Areas accessible to tillage equipment are cultivated. Most areas are small and are managed along with the Colo, Nodaway, or Zook soils on bottom lands.

Representative profile of Spillville loam, 1 to 3 percent slopes, 580 feet south and 160 feet east of the northwest corner of SW¼NE¼ sec. 1, T. 81 N., R. 30 W., on a first bottom land of 1 percent:

A1—0 to 15 inches, black (10YR 2/1) heavy loam; weak, medium and fine, granular structure; friable; neutral; gradual, smooth boundary.

A12—15 to 28 inches, black (10YR 2/1) to very dark brown (10YR 2/2) heavy loam; weak, medium and fine, granular structure; friable; neutral; diffuse, smooth boundary.

A13—28 to 40 inches, very dark brown (10YR 2/2) heavy loam; very weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

C1—40 to 52 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (2.5Y 4/2) light loam to heavy fine sandy loam; common, fine, faint, dark-brown (10YR 3/3) mottles and few, fine, distinct, brown (7.5YR 4/4) mottles; massive; friable; neutral; gradual, smooth boundary.

C2—52 to 60 inches, dark grayish-brown (2.5Y 4/2) to grayish-brown (2.5Y 5/2) fine sandy loam; common fine, faint, dark-brown (10YR 3/3) mottles and few, distinct, very dark gray (10YR 3/1) mottles; single grain; very friable; mildly alkaline.

The surface layer is black and very dark brown grading to very dark gray and very dark grayish-brown, friable loam 3 to 4 feet thick. The substratum is very dark gray, very dark grayish-brown, dark grayish-brown, or grayish-brown, friable loam or very friable sandy loam. A few mottles of dark brown, brown, and yellowish brown are at a depth below 40 inches. These soils are neutral to slightly acid in the substratum.

Spillville soils are loamy in the upper 40 inches rather than silty as are Kennebec soils. They have a thicker dark surface layer and lack the brown clay loam subsoil of Olmitz soils. Spillville soils are not stratified, and they are not so light colored or so silty in the upper 40 inches as the Nodaway soils.

Spillville loam, 1 to 3 percent slopes (485A).—About half of this soil is nearly level on first bottom lands adjacent to Colo or Nodaway soils. The remaining part is on concave, low foot slopes below Clarion and Storden soils. Areas are about 5 to 20 acres in size.

Areas on foot slopes are somewhat browner in the substratum than is representative for the series. Included with this soil in mapping are a few areas that are dark grayish brown at a depth of about 30 inches. Also included are some soils that have slopes of up to 5 percent.

There are no serious limitations to use of this soil for crops. In a few places this soil should be protected from runoff and occasional flooding. Generally these slight limitations do not constitute a hazard.

Large areas or areas that are accessible to tillage equipment are cultivated. This soil is well suited to row crops. Most of this soil is managed along with Colo or other bottom-land soils. (Capability unit I-3; woodland suitability group 8)

Storden Series

The Storden series consists of deep, moderately dark colored, well-drained, loamy soils on uplands. Stones and pebbles are common throughout, and there is abundant lime. Storden soils are only in the northeastern part of the county. They are on sharply convex knolls and side slopes. Individual areas range from 5 to 20 acres in size. Slopes range from 5 to 25 percent.

Storden soils formed in calcareous loamy till that is 20 or more feet thick. Beneath the till in places are several feet of silts; a gray, clayey, buried soil; clay loam till; or sediments from glacial till. In most places 20 to more than 50 feet of clay loam till is below the loam till. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown loam about 5 inches thick. Beneath this is a transitional layer of very dark grayish-brown and brown, friable loam about 4 inches thick. The underlying substratum, to a depth of 28 inches, is yellowish-brown and brown loam. Below this, it is mixed pale-brown, grayish-brown, and light-gray loam.

These soils have high available water capacity, but they are droughty in some years because of rapid runoff. They are moderately permeable. The water table is at a depth below 5 feet and is generally lacking to a depth of many feet. The surface layer is generally mildly alkaline and high in lime. These soils are very low in available nitrogen and very low to low in available phosphorus and potassium.

Runoff and low fertility are severe limitations. Storden soils erode if the surface layer is bare or if vegetation is sparse.

The less sloping Storden soils are cultivated along with the associated Clarion soils. The steeper areas are used as pasture.

Representative profile of Storden loam, 14 to 18 percent slopes, moderately eroded, 650 feet south and 150 feet east of the northwest corner of sec. 5, T. 81 N., R. 30 W., on a side slope of 15 percent:

A1—0 to 5 inches, very dark brown (10YR 2/2) loam; moderate, medium and fine, granular structure; friable; few pebbles; slightly effervescent; mildly alkaline; clear, smooth boundary.

AC—5 to 9 inches, very dark grayish-brown (10YR 3/2) and brown (10YR 5/3) loam; moderate, medium, granular structure; friable; some pebbles; strongly effervescent; mildly alkaline; clear, smooth boundary.

C1—9 to 19 inches, yellowish-brown (10YR 5/4) medium to heavy loam; few, fine, distinct, strong-brown (7.5YR 5/6) mottles; very weak, fine and very fine, subangular blocky structure; friable; few, soft, lime accumulations; few, medium, black oxides; some pebbles; strongly effervescent; mildly alkaline; clear, smooth boundary.

C2—19 to 28 inches, brown (10YR 5/3) heavy loam; many, medium, faint, yellowish-brown (10YR 5/4) mottles; massive to very weak, coarse, subangular blocky structure; friable; few, fine, prominent, yellowish-red (5YR 4/6), soft iron accumulations; many lime concretions; some pebbles; strongly effervescent; mildly alkaline; gradual, smooth boundary.

C3—28 to 60 inches, mixed pale-brown (10YR 6/3), grayish-brown (2.5Y 5/2) and light-gray (5Y 6/1) heavy loam; common, coarse, distinct, strong-brown (7.5YR 5/6) mottles; very weak, coarse, subangular blocky structure to massive; friable; few, fine, black oxides; few, fine, prominent, yellowish-red (5YR 4/8), soft iron accumulations; some pebbles; strongly effervescent; mildly alkaline.

The surface layer is very dark brown, very dark grayish-brown, or brown, friable loam less than 7 inches thick. In places a transitional layer between the surface layer and substratum is brown, very dark grayish-brown, or dark yellowish-brown, friable loam as much as 6 inches thick. The substratum is brown, yellowish-brown, or light olive-brown, friable loam to a depth between 24 to 36 inches. Mottles are usually below this depth. They are grayish brown to gray, olive gray, or strong brown. These soils are mildly alkaline to moderately alkaline and generally have carbonates throughout the profile.

Storden soils have a thinner surface layer than Clarion or Shelby soils and have carbonates throughout the profile. They are also not so high in content of clay or so firm in the substratum as Shelby soils. Storden soils are not so gravelly or sandy in the substratum as Salida soils.

Storden loam, 5 to 9 percent slopes, moderately eroded (62C2).—Most of this soil is on short, convex side slopes adjacent to steep Storden soils. Other areas are on sharply convex knolls associated with Clarion soils. Areas are less than 10 acres in size. This soil has a profile similar to the one described as representative for the series, but areas in pasture have a slightly thicker surface layer.

In places, the yellowish-brown substratum is exposed. These are shown on the soil map by a symbol for severely eroded spots. Included with this soil in mapping are small areas of Salida soil, which are indicated on the map by a symbol for gravel spots.

Runoff erodes the surface layer if vegetation is sparse. Most of this soil is cultivated along with Clarion soils or other Storden soils. It is well suited or moderately well suited to row crops if erosion is controlled and fertility is improved. The shape and small size of some areas make it difficult to control erosion. Areas that are in pasture generally are adjacent to steeper Storden soils. (Capability unit IIIe-3; woodland suitability group 3)

Storden loam, 9 to 14 percent slopes, moderately eroded (62D2).—This soil is on short, convex side slopes. It is adjacent to Clarion soils and upslope from steeper Storden soils or Spillville and Colo soils. Areas are about 5 to 10 acres in size, but some areas are larger.

This soil has a profile similar to the one described as representative for the series, but areas in pasture generally have a thicker dark surface layer and lack lime in the surface layer in places. A large acreage is eroded, and eroded areas have the yellowish-brown substratum exposed on the surface. These areas are indicated on the soil map by a symbol for severely eroded spots.

Erosion is a hazard if vegetation is sparse. Water that falls on the surface layer runs off before all of it is absorbed.

About one-half of this soil is cultivated. It is moderately well suited to row crops if erosion is controlled and fertility is improved. The remaining part is in pasture. Because of the size and shape of some of the areas in pasture, this is often a better use than for crops. Nearly all of this soil is managed with the associated Clarion and steeper Storden soils. (Capability unit IIIe-4; woodland suitability group 3)

Storden loam, 14 to 18 percent slopes, moderately eroded (62E2).—This soil is on short, convex side slopes. It is upslope from Spillville, Colo, and Zook soils and downslope from Clarion soils or less sloping Storden soils. Individual areas range from 5 to 20 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are about 90 acres of a Storden soil that has a somewhat darker and thicker surface layer and a few areas where the surface layer is not high in content of lime. Also included are a few small spots where the yellowish-brown substratum is exposed on the surface. These are indicated on the map by a symbol for severely eroded spots.

Erosion is a hazard if the surface is bare or if vegetation is sparse. Because of rapid runoff, this soil is droughty during periods of low rainfall.

Much of this soil is in pasture. Small areas surrounded by less sloping soils are cultivated in places. This soil is suited to pasture. It is poorly suited to row crops, even if erosion is controlled and fertility is improved. (Capability unit IVe-2; woodland suitability group 3)

Storden loam, 18 to 25 percent slopes, moderately eroded (62F2).—This soil is on short, convex side slopes. It is upslope from Spillville, Colo, and Zook soils and downslope from Clarion soils or less sloping Storden soils. Areas range from about 5 to 20 acres in size.

Included with this soil in mapping are some soils that have slopes of about 30 percent, and a few soils that are not high in content of lime in the surface layer or to a depth of about 2 feet. Also included are some soils on escarpments adjacent to stream benches that are underlain by sands and gravel, and a few, small, eroded areas where the yellowish-brown substratum is exposed on the surface. These areas are indicated on the map by a symbol for severely eroded spots.

Erosion is a hazard, and low fertility limits plant growth. Water that falls on the surface layer runs off before all of it is absorbed. Because of rapid runoff this soil is droughty during periods of low rainfall.

Almost all of this soil is in pasture, and it is suited to this use. It is managed as separate fields or along with the steep adjacent soils. Some areas are so steep that tillage equipment cannot be used safely. (Capability unit VIe-2; woodland suitability group 4 or 5)

Vesser Series

The Vesser series consists of deep, dark-colored, poorly drained, silty soils on bottom lands and low concave foot slopes. These soils are mainly along Brushy Creek and the South Raccoon River. Individual areas range from 10 to about 40 acres in size. Slopes range from 0 to 2 percent.

Vesser soils formed in silty alluvium 5 to more than 10 feet thick. Beneath this, the alluvium generally consists of stratified loamy and sandy materials to a depth of 20 feet or more. On foot-slope positions, the silty alluvium is underlain by glacial till or till-derived sediments in places. The native vegetation was grasses and sedges tolerant to excessive wetness.

In a representative profile, the surface layer is black and very dark gray silt loam about 19 inches thick. Below this is a distinct subsurface layer of dark-gray, friable silt loam about 15 inches thick. This layer is distinctly light colored when dry. The subsoil extends to a depth of nearly 68 inches and is mottled, dark-gray and gray, friable light silty clay loam. Beneath this, the substratum is mottled, gray, friable silt loam.

Vesser soils have high available water capacity. They are moderately permeable. Vesser soils have a high water table unless artificially drained. The surface layer is generally slightly acid, and in some areas it is more acid unless limed. These soils are low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Most areas of Vesser soils are artificially drained or partly drained. Wetness is a hazard, and in bottom-land areas water ponds on the surface in places. The soil dries out somewhat slowly after rains and is easily puddled if worked when wet. Some areas flood, and recent less fertile sediments are deposited on the surface layer.

Most areas are cultivated. Some Vesser soils are in large areas that can be managed as separate fields, but most soils are managed along with the associated Colo and Zook soils.

Representative profile of Vesser silt loam, 0 to 2 percent slopes, 135 feet north and 365 feet east of the southwest corner of NW¼NE¼ sec. 26, T. 79 N., R. 31 W., on a slope of 1 percent:

Ap—0 to 8 inches, black (10YR 2/1) to very dark gray (10YR 3/1) silt loam; cloddy breaking to weak, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A12—8 to 14 inches, very dark gray (10YR 3/1) silt loam; weak, medium, subangular blocky structure breaking to weak, medium, granular; friable; slightly acid; clear, smooth boundary.

A13—14 to 19 inches, very dark gray (10YR 3/1) silt loam; moderate, very fine, subangular blocky structure; friable; light brownish-gray (2.5Y 6/2) silt coatings when dry; slightly acid; clear, smooth boundary.

A2—19 to 34 inches, dark-gray (10YR 4/1) silt loam; faint dark-brown (10YR 3/3) mottles; very weak, medium, platy structure breaking to weak, very fine and fine, subangular blocky; friable; light-gray (2.5Y 7/2) silt coatings when dry; slightly acid; clear, smooth boundary.

B21tg—34 to 43 inches, dark-gray (10YR 4/1) light silty clay loam; common, fine, distinct, dark-brown (7.5YR 3/2) mottles; very weak, medium, prismatic structure breaking to moderate, medium, subangular blocky; friable; very few, thin, discontinuous, clay films; few, fine, black oxides; slightly acid; diffuse, smooth boundary.

B22tg—43 to 56 inches, gray (10YR 5/1) light silty clay loam; common, fine, distinct dark-brown (7.5YR 3/2) mottles; weak, medium, prismatic structure breaking to moderate, medium, subangular blocky; friable; few, thin, discontinuous clay films; common, fine, black oxides; slightly acid; diffuse, smooth boundary.

B3g—56 to 68 inches, gray (10YR 5/1) light silty clay loam; many, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; slightly acid; gradual, smooth boundary.

Cg—68 to 72 inches, gray (10YR 5/1) silt loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; massive; friable; slightly acid.

The surface layer is black or very dark gray, friable silt loam to light silty clay loam 12 to 20 inches thick. The subsurface layer is dark-gray, dark grayish-brown, or gray, friable silt loam 12 to 20 inches thick. The subsoil is dark-gray, gray, or olive-gray, friable or firm light to medium silty clay loam 30 to 40 inches thick. The subsoil is mottled with light olive brown, dark brown, brown, yellowish brown, or strong brown. Depth to the substratum ranges from 50 to 70 inches. The substratum ranges from silt loam or silty clay loam to loam and has colors and mottles similar to the subsoil. These soils are slightly acid to medium acid in the upper part of the subsoil. The lower part of the subsoil and the substratum are slightly acid to neutral.

These soils have a thicker subsurface layer and less clay in the subsoil than Humeston soils. They have a grayish subsurface layer and a gray, mottled subsoil that differ from Judson and Ely soils. Vesser soils have more developed profiles than Colo soils, and they have a grayish subsurface layer and are not dark colored to as great a depth.

Vesser silt loam, 0 to 2 percent slopes (51A).—This soil is in flat or slightly depressed areas on first bottom lands. Areas are some distance from the river channel near the foot slopes on uplands. This soil is adjacent to Colo and

Zook soils and downslope from Ely, Judson, or Olmitz soils. Areas are about 20 to 40 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few soils that have a slightly greater clay content in the subsoil. Also included are about 90 acres of Vesser silt loam on foot slopes of 2 to 5 percent.

This soil is wet unless artificially drained. It has a high water table and is subject to flooding and ponding during periods of high rainfall. Even if drained, the surface layers dry out somewhat slowly.

It is well suited to row crops if wetness is controlled. Most of this soil is managed along with the associated Colo and Zook soils. (Capability unit IIw-2; woodland suitability group 9)

Vesser silt loam, overwash, 0 to 2 percent slopes (51A+).—This soil is on flat or slightly depressed bottom lands. Most of it is adjacent to tributary streams or foot slopes. It is adjacent to Colo and Zook soils and downslope from Shelby, Sharpsburg, Ely, Judson, or sloping Colo soils. Areas are about 10 to 20 acres in size.

This soil has a profile similar to the one described as representative for the series, but the surface layer is depositional material that is very dark grayish-brown, friable silt loam about 6 to 12 inches thick.

Included with this soil in mapping are a few areas that have a slightly greater content of clay in the subsoil than is representative.

This soil is wet. It floods during periods of high rainfall, and the water table is high unless artificially drained. The recently deposited surface layer is less fertile than that of Vesser silt loam, 0 to 2 percent slopes.

Most of the large areas are cultivated. This soil is well suited to row crops if wetness is controlled. Most of this soil is managed along with the surrounding Ely, Judson, Colo, or Zook soils. (Capability unit IIw-2; woodland suitability group 9)

Wadena Series

The Wadena series consists of dark-colored, well-drained, loamy soils that are deep and moderately deep to underlying sand and gravel. They are on benches in the northeastern part of the county. Areas range from 5 to 20 acres in size. Slopes range from 0 to 14 percent.

Wadena soils formed in about 24 to 40 inches of loamy alluvium. This is underlain by calcareous sandy and gravelly alluvium that is 4 to many feet thick. In some places glacial till or sediments from glacial till are below the coarse materials. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black, very dark brown, and very dark grayish-brown, friable loam about 16 inches thick. The subsoil is brown, friable gravelly loam about 11 inches thick. The underlying substratum is brown, loose gravelly loamy sand and medium loamy sand.

Wadena soils have moderate or low available water capacity, depending upon the depth to sand and gravel. They are moderately permeable in the upper loamy material and very rapidly permeable in the sandy and gravelly materials. The water table is below a depth of 5 feet, and the underlying sands are generally not saturated. The surface layer is slightly acid, but some areas are more acid and need additions of lime. Wadena soils are low in available nitrogen and phosphorus and medium in available potassium.

These soils warm up quickly in the spring and can be worked soon after rains. The Wadena, moderately deep, soils are generally droughty during periods of low rainfall. The Wadena, deep, soils are somewhat droughty during these periods. Runoff erodes the sloping soils if vegetation is sparse.

Almost all of the Wadena soils are cultivated. They are generally managed along with the Cylinder soils and some soils included with the Webster and Canisteo soils.

Representative profile of Wadena loam, moderately deep, 0 to 2 percent slopes, 1,210 feet north and 336 feet east of the southwest corner of SE¼SW¼ sec. 27, T. 81 N., R. 30 W., on a bench of 1 percent slope:

Ap—0 to 8 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A12—8 to 12 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A3—12 to 16 inches, very dark grayish-brown (10YR 3/2) loam; weak, medium, subangular blocky structure; friable; neutral; clear, smooth boundary.

B2—16 to 27 inches, brown (10YR 4/3) gravelly loam; weak, fine, subangular blocky structure to single grain; friable; neutral; clear, smooth boundary.

C1—27 to 60 inches, brown (10YR 4/3) gravelly loamy sand; single grain; loose; strongly effervescent; mildly alkaline; diffuse, smooth boundary.

C2—60 to 72 inches, brown (10YR 4/3) to dark yellowish-brown (10YR 4/4) medium loamy sand; single grain; loose; strongly effervescent; mildly alkaline.

The surface layer is black, very dark brown, very dark gray, and very dark grayish-brown, friable loam 10 to 18 inches thick. The subsoil is brown, dark yellowish-brown, or olive-brown, friable loam 10 to 24 inches thick. The lower part of the subsoil contains gravel in places, and some profiles have thin layers of sandy loam material. The underlying sand, loamy sand, and gravel is at a depth between 24 and about 40 inches. A moderately deep and deep phase is mapped in this county. The coarse-textured substratum is calcareous and is brown, dark yellowish brown to yellowish brown, and olive brown to light olive brown. These soils are slightly acid to neutral in the subsoil. The underlying sand and gravel are calcareous.

These soils have a browner subsoil than the somewhat poorly drained Cylinder soils. They are not so shallow to sand and gravel or carbonates as are Salida soils. Wadena soils are not so sandy in the upper part of the profile as Dickinson soils and are more gravelly in the substratum.

Wadena loam, deep, 0 to 2 percent slopes (308A).—This soil is on stream benches of valleys in the northeastern part of the county. It is on the most level part of the bench adjacent to Cylinder soils. It is upslope from more sloping Wadena soils. Individual areas are 5 to 20 acres in size.

This soil has about 40 inches of loamy material over sand and gravel. The depth to coarse material is 36 to 48 inches in places.

Included with this soil in mapping are a few soils that are more acid. In these places the underlying materials are partly leached of carbonates.

This soil is somewhat droughty during prolonged dry periods. Nearly all of the soil is cultivated. It is well suited to row crops. Most of the soil is managed along with the associated Cylinder soils. A few areas are managed with the upland, till-derived soils, such as those of

the Clarion series. (Capability unit I-2; woodland suitability group 1)

Wadena loam, deep, 2 to 5 percent slopes (308B).—This soil is on short, convex slopes bordering stream benches in the northeastern part of the county. It is downslope from Cylinder soils and less sloping Wadena soils. Steeper Wadena soils or soils on bottom lands are at a lower elevation. Individual areas range from 5 to 20 acres in size.

This soil has about 40 inches of loamy material over sand and gravel. In places the depth to coarse materials ranges from 36 to 48 inches.

Included with this soil in mapping are some soils that are slightly more acid. Also included are a few soils that are underlain by sandy loam materials to a depth of about 4 feet.

Runoff erodes this soil if the surface is bare or if vegetation is sparse. This soil is somewhat droughty during prolonged dry periods.

Most of this soil is cultivated. It is well suited to row crops if erosion is controlled. This soil is generally managed along with other Wadena soils and the Cylinder soils. (Capability unit IIe-2; woodland suitability group 1)

Wadena loam, deep, 5 to 14 percent slopes (308C).—This soil is in short, convex slopes that border stream benches in the northeastern part of the county. It is downslope from Cylinder soils and less sloping Wadena soils and upslope from soils on first bottom lands. Individual areas range from 5 to 20 acres in size, but most areas are less than 10 acres.

This soil has about 40 inches of loamy materials over sand and gravel. In places the depth to coarse materials ranges from 36 to 44 inches.

Included with this soil in mapping are some soils that are slightly more acid. Also included are a few moderately eroded areas in which the depth to coarse materials is about 30 inches.

Runoff erodes this soil if vegetation is sparse. This soil is also somewhat droughty during prolonged dry periods.

It is moderately well suited to well suited to row crops if erosion is controlled. Nearly all of this soil is managed along with less sloping Wadena soils and the Cylinder soils. Small areas associated with Salida soils are left idle or are in pasture in some places. (Capability unit IIIe-3; woodland suitability group 1)

Wadena loam, moderately deep, 0 to 2 percent slopes (108A).—This soil is on the more level part of stream benches in the northeastern part of the county. It is adjacent to Wadena, deep, soils and Cylinder soils. It is upslope from more sloping Wadena soils. Individual areas are 5 to more than 10 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few areas that have a sandy loam subsoil. Sand and gravel are generally at a depth between 24 and 36 inches.

This soil is somewhat droughty. In years of average or below average rainfall, lack of moisture limits plant growth late in July and August.

All of this soil is cultivated. It is well suited to row crops. Areas are small and are generally managed along with the surrounding Wadena or Cylinder soils. (Capability unit IIs-1; woodland suitability group 1)

Wadena loam, moderately deep, 2 to 5 percent slopes (108B).—This soil is mainly on stream benches or short side slopes of benches in the northeastern part of the county. It is mostly surrounded by other Wadena soils, but a few areas are on uplands and adjacent to Salida soils. Individual areas are 5 to 20 acres in size. This soil has a profile similar to the one described as representative for the series, except that sand and gravel are at a depth between 24 and 36 inches.

Included with this soil in mapping are about 120 acres of a soil that has a sandy loam subsoil and soils that are shallower to carbonates and sand or gravel.

Runoff erodes this soil if vegetation is sparse. It is somewhat droughty because runoff does not permit all the moisture that falls to be absorbed and because the storage capacity for moisture is limited. In years of average or below average rainfall, plant growth is limited late in July and in August.

Most of this soil is cultivated. It is well suited to row crops if erosion is controlled. This soil is managed along with the surrounding Wadena soils. (Capability unit IIe-2; woodland suitability group 1)

Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded (108C2).—This soil is mainly on short, convex side slopes bordering stream benches in the northeastern part of the county. In a few places it is on uplands and adjacent to Salida soils. Most of this soil is downslope from less sloping Wadena and Cylinder soils. It is upslope from soils on first bottom lands. Individual areas range from 5 to 20 acres in size.

This soil has a surface layer of very dark brown or very dark grayish-brown loam. The brownish subsoil is mixed with the plow layer in a few small areas.

Included with this soil in mapping are a few soils that have a sandy loam subsoil and a shallower depth to sand and gravel.

Runoff erodes this soil if vegetation is sparse. This soil is somewhat droughty. Some rainfall is lost by runoff and the storage capacity for moisture is limited. In years of average or below average rainfall, plant growth is restricted late in July and in August.

Nearly all of this soil is cultivated. It is moderately well suited to well suited to row crops if erosion is controlled. Areas of this soil are generally small and are managed along with the surrounding Wadena, Cylinder, or Salida soils. (Capability unit IIIe-3; woodland suitability group 1)

Webster Series

The Webster series consists of deep, dark-colored, poorly drained, loamy soils on uplands. They are in irregularly shaped swales and draws. All of these soils are in the northeastern part of the county. Individual areas are about 10 to more than 80 acres in size. Slopes range from 0 to 2 percent.

Webster soils formed in glacial till sediments and loam glacial till. The till is about 20 feet or more in thickness. Below this, there is generally silt several feet thick underlain by a gray, clayey, buried soil. Beneath the buried soil is about 50 feet or more of clay loam till. The native vegetation was grasses and sedges tolerant to excess wetness.

In a representative profile, the surface layer is black silty clay loam about 21 inches thick. The subsoil extends to a depth of 40 inches. It is very dark gray to very dark grayish-brown, friable silty clay loam in the upper part and dark-gray, gray, and olive-gray, friable clay loam in the lower part. Beneath this, the substratum is pale-olive, light olive-gray, and gray and light-gray, friable loam that contains carbonates. Mottles of strong brown and yellowish brown are in the lower part of the subsoil and in the substratum.

Webster soils have high available water capacity. They are moderately permeable or moderately slowly permeable. They have a high water table. The surface layer is generally neutral and does not need liming. These soils are low to medium in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Webster soils are wet unless artificially drained. Runoff from soils upslope collects in areas of Webster soils after heavy rains. Even when drained, they dry out slowly after rains and puddle easily. Nearly all of these soils are drained or partly drained.

Nearly all areas are cultivated. Most areas are so irregular in shape that they are managed along with the associated Okoboji, Harps, and Clarion soils.

Representative profile of Webster silty clay loam, 210 feet north and 120 feet west of the southeast corner of NW¼ sec. 29, T. 81 N., R. 30 W., in an upland swale of 1 percent slope:

A11—0 to 7 inches, black (N 2/0) light silty clay loam; moderate, very fine, subangular blocky structure breaking to weak, fine, granular; friable; sand grains evident; neutral; clear, smooth boundary.

A12—7 to 17 inches, black (10YR 2/1 to N 2/0) light to medium light silty clay loam; weak to moderate, fine, subangular blocky structure; friable; sand grains evident; neutral; gradual, smooth boundary.

A13—17 to 21 inches, black (10YR 2/1 to N 2/0) to very dark gray (N 3/0) light to medium silty clay loam; weak to moderate, fine, subangular blocky structure; friable; very common very dark grayish-brown (10YR 3/1) coatings on peds; sand grains evident; neutral; clear, smooth boundary.

B1g—21 to 24 inches, very dark gray (N 3/0) to very dark grayish-brown (2.5Y 3/2) light to medium silty clay loam, very dark gray (10YR 3/1) when kneaded; weak to moderate, fine, subangular blocky structure; friable; very common, shiny, dark-gray (5Y 4/1) coatings on peds; many sand grains evident; neutral; clear, smooth boundary.

B2g—24 to 33 inches, dark-gray (5Y 4/1) light silty clay loam to clay loam; weak to moderate, fine, subangular blocky structure; friable; common dark-gray (N 4/0) coatings on peds; some fine pebbles; mildly alkaline; clear, smooth boundary.

B3g—33 to 40 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) light clay loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; very weak, fine, subangular blocky structure; friable; dark-gray (N 4/0) fills in worm channels; few lime concretions; few pebbles; slightly effervescent; mildly alkaline; clear, smooth boundary.

C1g—40 to 43 inches, pale-olive (5Y 6/3) heavy loam; few, fine and medium, prominent, strong-brown (7.5YR 5/8) mottles; massive; friable; streaks of dark gray (N 4/0); few lime concretions; some pebbles; strongly effervescent; mildly alkaline; abrupt, smooth boundary.

C2g—43 to 47 inches, light olive-gray (5Y 6/2) heavy loam; common, medium, prominent, strong-brown (7.5YR 5/6) mottles; massive; friable; few, medium, black oxides; few lime concretions; some pebbles; strongly effervescent; moderately alkaline; abrupt, smooth boundary.

C4g—47 to 60 inches, gray to light-gray (5Y 5/1 to 6/1) heavy loam; few, medium, prominent, yellowish-brown (10YR 5/6) mottles; massive; friable; few lime concretions; some pebbles; strongly effervescent; moderately alkaline.

The surface layer is black to very dark gray, friable silty clay loam to clay loam 18 to 24 inches thick. The surface layer has enough sand to feel gritty. The subsoil is in hues of 10YR or 2.5Y. It is dark gray to very dark grayish brown in the upper part and dark gray, gray, grayish brown, or olive gray in the lower part. It ranges from silty clay loam to a clay loam and generally contains 28 to 35 percent clay. The silty clay loam has enough sand to feel gritty. It is 16 to 24 inches thick. Mottles of light olive brown, yellowish brown, and strong brown are in the subsoil and substratum. The substratum is pale-olive, light olive-gray, olive-gray, gray, or light-gray loam or light clay loam. Carbonates are at a depth of 30 to 40 inches.

Webster soils are grayer in the subsoil and more clayey in the upper 2 feet of the profile than Nicollet soils. They are more loamy in the subsoil, and less clayey than Okoboji soils, and they are not dark colored to so great a depth. They lack the high carbonate content of Harps or Canisteo soils.

Webster silty clay loam (0 to 2 percent slopes) (107).—This soil is in irregularly shaped, concave swales and draws on uplands. It is downslope from Clarion and Nicollet soils. It is not in distinct depressions as are Okoboji soils. Individual areas are 10 to more than 80 acres in size.

Included with this soil in mapping are about 350 acres in Victory, Cass, and Jackson Townships north of the Raccoon River that are underlain by firm clay loam till at a depth of about 30 inches. The upper part of the profile in these areas is light to medium silty clay loam and the lower part is firm clay loam. Also included are a few areas on stream benches that are underlain by stratified materials at a depth below 4 feet. Also included are small areas similar to the Harps soils that are calcareous and small areas similar to the Okoboji soils that contain crossable depressions.

All of this soil is artificially drained or partly drained and cultivated. It is well suited to row crops if wetness is controlled. Soil blowing occurs if large areas are plowed in fall. The surface layer puddles easily if worked when wet.

All of this soil is managed along with the surrounding Harps, Okoboji, Nicollet, and Clarion soils. (Capability unit IIw-1; woodland suitability group 9)

Zook Series

The Zook series consists of deep, dark-colored, poorly drained, silty soils on bottom lands. These soils are on the lowest part of first bottom lands a distance from the river channel and near the base of foot slopes and stream benches. Individual areas range from 10 to more than 80 acres. Slopes range from 0 to 2 percent.

Zook soils formed in silty clay loam and silty clay alluvium that is 4 to more than 20 feet thick in places. Below this is stratified loamy and sandy alluvium many feet thick. The native vegetation was grasses and sedges tolerant to excessive wetness.

In a representative profile, the surface layer is black light to heavy silty clay loam about 26 inches thick. The subsoil extends to a depth of about 49 inches. It is very dark gray, firm medium to heavy silty clay loam that has

some mottles of brown and dark yellowish brown. Below this, the substratum is dark-gray, firm medium silty clay loam. Mottles similar to those in the subsoil are evident and are generally more numerous.

These soils have high available water capacity. They are slowly permeable. They have a high water table unless artificially drained. The surface layer is generally slightly acid to neutral in reaction. It is more acid in places and needs additions of lime. Zook soils are medium to low in available nitrogen, very low to low in available phosphorus, and medium in available potassium.

The Zook soils are wet unless artificially drained. Some areas flood in periods of high rainfall. They dry out slowly after rain, and the surface layer puddles easily if worked when wet.

Most of the Zook soils are cultivated if they are artificially drained or partly drained. Many areas are large enough to be managed as separate fields. Others are managed along with the surrounding Colo, Humeston, Vesser, or Nodaway soils.

Representative profile of Zook silty clay loam, 460 feet south and 57 feet east of the northwest corner of SW¼SW¼ sec. 36, T. 78 N., R. 32 W., on a first bottom land of about 1 percent slope:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam; cloddy breaking to weak, fine and very fine, granular structure; friable; slightly acid; clear, smooth boundary.

A12—7 to 18 inches, black (N 2/0) medium silty clay loam, black (10YR 2/1) when kneaded; weak, medium, subangular blocky structure breaking to moderate, fine, granular; friable; neutral; gradual, smooth boundary.

A13—18 to 26 inches, black (N 2/0) heavy silty clay loam; strong to moderate, very fine, subangular blocky structure; firm; slightly acid; gradual, smooth boundary.

B1g—26 to 37 inches, very dark gray (10YR 3/1 to N 3/0) heavy silty clay loam; few, fine, faint, dark yellowish-brown (10YR 3/4) mottles; weak, fine to medium, subangular blocky structure; firm; slightly acid; gradual, smooth boundary.

B2g—37 to 49 inches, very dark gray (N 3/0 to 10YR 3/1) medium silty clay loam; common, fine, prominent, brown (7.5YR 4/4) mottles; weak, fine to medium, subangular blocky structure; firm; neutral; gradual, smooth boundary.

Cg—49 to 60 inches, dark-gray (5Y 4/1) medium silty clay loam; common, medium, prominent, brown (7.5YR 4/4) mottles; massive; firm; few, dark-gray (N 4/0) fine streaks and coatings in root channels; neutral.

The surface layer is black, friable light silty clay loam to firm heavy silty clay loam 24 to 30 inches thick. The subsoil is very dark gray to dark gray, firm heavy silty clay loam or light silty clay 12 to 24 inches thick. Very dark gray or darker colors extend to a depth of 36 inches or more. The substratum is dark-gray, gray, or olive-gray, firm medium silty clay loam to light silty clay. Mottles of brown, dark yellowish brown, yellowish brown, or light olive brown are in the lower part of the subsoil and in the substratum. These soils are slightly acid or neutral in all parts of the subsoil and in the substratum.

Zook soils are higher in clay content throughout their profile than Colo soils. They are darker colored to a greater depth and have a less developed subsoil than Humeston and Vesser soils and they lack a grayish subsurface layer. Zook soils also have more clay in the subsoil than Vesser soils.

Zook silt loam, overwash (0 to 2 percent slopes) (54+).—This soil is on low bottom lands. Some areas are adjacent to river channels or near tributary streams that drain to major rivers. Individual areas range from 10 to more than 40 acres in size.

This soil has about 6 to 18 inches of stratified very dark grayish-brown and dark grayish-brown silt loam sediment deposited over a buried Zook soil.

Wetness, flooding, and sedimentation are hazards to farming. The recent sediment now on the surface is less fertile than the original dark surface layer. The surface layer dries out somewhat sooner than in typical Zook soils.

This soil is well suited to row crops if wetness and flooding are controlled. It is mostly managed along with the surrounding Zook, Colo, and Nodaway soils. (Capability unit IIw-2; woodland suitability group 9)

Zook silty clay loam (0 to 2 percent slopes) (54).—This soil is on low bottom lands. It is generally some distance from the river channel and near the base of foot slopes or stream benches. Individual areas range from 10 to 80 acres. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few areas that are dark gray at a depth of about 30 to 36 inches. These places are slightly more mottled than is typical for Zook soils. Also included are a few areas that have a more strongly developed subsoil.

This soil is wet unless artificially drained. Runoff is very slow. The surface layer dries out slowly after rains, and tillage operations are delayed. In places diversion terraces are used to prevent runoff from uplands from collecting on this soil (fig. 10).

This soil is well suited to row crops if wetness is controlled. Much of it is managed as separate fields. Some areas are managed along with the Colo, Humeston, Vesser, or other Zook soils. (Capability unit IIw-2; woodland suitability group 9)

Use and Management of the Soils

This section describes the system of capability classification used by the Soil Conservation Service and discusses the use and management of groups of soils, or capability units. There is a table showing yield estimates of the major crops for the soils in the county. Also in this section is discussed the use of the soils for woodland, wildlife, and recreation. And finally the use of the soils for engineering is discussed.

Use of the Soils for Crops and Pasture

In Guthrie County about 228,000 acres, or about 60 percent of the county, is used for crops. About 116,000 acres, or about 30 percent, is used for pasture. Much of the 38,000 acres that is wooded is also used for pasture.

Corn, soybeans, oats, and legumes and legume-grass hay are the main crops. Minor crops include sudangrass, which is used for pasture, and sorghums, which are mainly harvested as silage.

Most pastures in the county are in permanent bluegrass. Some have been renovated, and plants, such as birdsfoot trefoil, have been introduced. Grasses, such as bromegrass, or grass-legume mixtures, such as alfalfa and bromegrass, are also planted in pasture.

Figure 10.—**Diversion terracing reduces wetness in Zook silty clay loam.**

Many soils in the county, including those of the Sharpsburg, Ladoga, and Shelby series, are subject to sheet erosion and gullying. Regular and grassed backslope terraces are used to control erosion on such soils.

Drain tiles are used to reduce wetness in such soils as the Webster, Canisteo, Okoboji, Colo, and Zook soils and the Colo-Judson and Colo-Spillville complexes. Interceptor tiles are used to reduce wetness in such soils as the Clearfield, Clarinda, and Lamoni soils. In places surface drains are used to remove excess water from soils, such as the Okoboji or Humeston soils.

Gully-control structures, farm ponds, and grassed waterways are used to control gullying in watercourses. The farm ponds furnish water for livestock, recreation, and other uses. In a few places levees are used to protect bottom lands from flooding.

Capability grouping

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on the limitations of the soils, the risk of damage when they are used for the ordinary field crops or sown pastures, and the way they respond to treatment. The classification does not apply to most horticultural crops or to rice and other crops that have special requirements for production. The soils are classified according to degree and kind of permanent limitations, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils, and without consideration of possible major reclamation.

In the capability system, all soils are grouped at three levels, the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groupings, are designated by Roman numerals I through VIII. The larger the numerals, the greater the limitations and narrower the choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion, but have other limitations, impractical to remove,

that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to wildlife habitat, water supply, or for recreational or esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion, unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils, the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* is used in those areas where climate is the chief limitation to the production of common cultivated crops.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIe-3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units are described; some limitations are given; and suitable management is briefly discussed. The names of soil series represented are mentioned in the descriptions of each capability unit, but this does not mean that all soils of a given series appear in the unit. To find the names of all the soils in any given capability unit, refer to the "Guide to Mapping Units" at the back of the survey.

CAPABILITY UNIT I-1

This unit consists of nearly level, moderately well drained and somewhat poorly drained, silty and loamy soils of the Ladoga, Macksburg, Nevin, Nicollet, and Sharpsburg series. They are mainly on uplands, but Nevin soils are on low stream benches.

The Ladoga, Macksburg, Nevin, and Sharpsburg soils have a friable, silty clay loam or silt loam surface layer and a silty clay loam subsoil. Nicollet soils have a loam surface layer and a light clay loam subsoil.

The available water capacity is high, and permeability is moderate to moderately slow. The organic-matter content is moderately low in Ladoga soils and moderate or high in the other soils. Natural fertility is medium or high.

Almost all areas of these soils are cultivated. They are well suited to row crops. Corn and soybeans are the major crops, but oats and hay are also important. An occasional catch crop is grown for green manure or a year of meadow is grown.

These soils are generally subject to only slight or no sheet and gully erosion. They hold a good supply of moisture available to plants. The response is good to large plant populations, high rates of fertilization, and the chemical control of weeds and insects. A few areas of Macksburg and Nicollet soils have tile drains, but in most areas these installations are incidental to the drainage of wetter adjacent soils. Most areas of these soils are farmed without artificial drainage. Corn responds well to additions of nitrogen and phosphorus fertilizer. Small amounts of potassium are generally beneficial. The soils are neutral to medium acid in the surface layer, and many areas need additions of lime.

CAPABILITY UNIT I-2

This unit consists of nearly level, well-drained and somewhat poorly drained, loamy soils of the Cylinder and Wadena, deep, series. They are on stream benches.

The Wadena and Cylinder soils have a friable loam surface layer and subsoil. They are underlain by sand and gravel at a depth of about 3½ feet. Gravel pits are in some areas.

The available water capacity is moderate, and permeability is moderate in the upper part of the profile and rapid or very rapid in the underlying sand and gravel. The organic-matter content is moderate or high. Natural fertility is medium or high.

Most of these soils are cultivated. They are well suited to row crops. Corn and soybeans are the major crops, but oats and hay and a small amount of grain sorghum are also grown. An occasional catch crop is grown for green manure or the rotation includes a year of meadow.

These soils are generally subject to only slight or no sheet and gully erosion. They hold a good supply of moisture available to plants, although in some years available moisture is limited. The sand and gravel beneath the soils restrict root development to some extent and influence available water capacity. These soils tend to be somewhat droughty in some years. Response is good to large plant populations, high rates of fertilization, and the chemical control of weeds and insects. In very wet periods, some Cylinder soils tend to be somewhat wet, but artificial drainage is seldom needed.

Corn responds well to nitrogen and phosphorus fertilizer. The response to small additions of potassium is generally good. The soils are generally neutral or slightly acid in the surface layer, but some areas are more acid. Many areas need liming.

CAPABILITY UNIT I-3

This unit consists of nearly level, moderately well drained or somewhat poorly drained, loamy and silty

soils of the Kennebec, Nodaway, and Spillville series. They are on first bottom lands.

The soils in this unit have a friable silt loam or loam surface layer and are similar in texture below. The Nodaway soil in the unit is light colored below the plow layer. The other soils are dark colored to a depth of about 40 inches or more.

The available water capacity is high, and permeability is moderate. The organic-matter content is low in Nodaway soil and moderate or high in the other soils. Natural fertility is medium or high.

Most areas of these soils are cultivated, and row crops are well suited. Corn and soybeans are the major crops, but oats, hay, and, occasionally, grain sorghum are also grown. An occasional catch crop is grown for green manure or a meadow crop is grown in some years.

These soils are not subject to erosion. They hold a good supply of moisture available to plants, and they generally hold more moisture than most soils in the county. Response is good to large plant populations, high rates of fertilization, and the chemical control of weeds.

These soils are subject to flooding for short periods when snow melts and runs off in spring or when rainfall is excessive. Although flooding generally occurs before crops are planted in spring, it is of short duration and crops are generally not damaged. In some places water from adjacent slopes runs across areas of these soils and causes them to be slightly wet when rainfall is above normal. In places diversion terraces can be placed upslope from these soils to protect them from runoff from higher areas. Contouring and terracing the soils upslope also helps to control runoff.

Corn responds well to addition of nitrogen and phosphorus fertilizer. Small amounts of potassium are usually beneficial. The soils generally are neutral or slightly acid in the surface layer, but they seldom need large additions of lime.

CAPABILITY UNIT IIe-1

This unit consists of well drained or moderately well drained, silty soils of the Clinton, Ladoga, Marshall, and Sharpsburg series. Slopes range from 2 to 5 percent. They are on uplands and on high benches near streams.

The soils in this unit have a friable, silt loam or silty clay loam surface layer and a silty clay loam subsoil.

The available water capacity is high, and permeability is moderate or moderately slow. The organic-matter content is typically low in the Clinton and Ladoga soils and moderate to high in the Marshall and Sharpsburg soils. Natural fertility ranges from low in the Clinton soils to high in the Sharpsburg and Marshall soils.

Most areas of these soils are cultivated. They are well suited to row crops if erosion is controlled. Corn and soybeans are the major crops, but oats and crops for rotation hay or pasture are also commonly grown.

These soils are subject to erosion. Terraces and contour tillage help to control erosion and runoff. Terracing is not practical in places on those soils that are on benches, because of the irregular slopes. In places runoff from the adjacent soils on uplands needs to be controlled before terraces are constructed in soils on the benches, and in places diversions are needed. Corn responds well to additions of nitrogen and phosphorus fertilizer. Small amounts of potassium are generally beneficial. The soils typically are slightly acid to strongly acid in the surface layer, and many areas need liming.

CAPABILITY UNIT IIe-2

This unit consists of well drained and moderately well drained, loamy soils of the Clarion, Lester, Shelby, and Wadena series on uplands and on stream benches. Slopes range from 2 to 5 percent.

The soils in this unit have a friable, loam and clay loam surface layer. The Wadena soils have sand and gravel in the substratum at a depth of about 2 to 3½ feet.

The available water capacity is generally high, but it is moderate or low in Wadena soils. Permeability is generally moderate or moderately slow, but it is moderate in the upper part of the profile of Wadena soils and very rapid in the underlying sand and gravel. The sand and gravel is shallow enough that the available moisture capacity is reduced in the Wadena soil and root growth is commonly restricted, especially in the moderately deep soil. The organic-matter content is generally moderate, but it is low in the Lester soil and the moderately eroded Clarion soils. Natural fertility is medium or high.

Most areas of these soils are cultivated. They are well suited to row crops if erosion is controlled. Corn and soybeans are the major crops, but oats and crops for rotation hay or pasture are also commonly grown.

These soils are subject to erosion. Wadena soils are droughty, especially the moderately deep soil. Terraces and contour tillage help to control erosion and runoff. Contour tillage to control erosion and runoff is better than terraces on the Wadena soils because they are underlain by sand and gravel, and terracing reduces available moisture capacity and organic-matter content. Corn responds well to additions of nitrogen and phosphorus fertilizer. Small additions of potassium are generally beneficial. Other crops also respond well to needed fertilizer. The soils generally are slightly acid or neutral in the surface layer, and some areas need liming.

CAPABILITY UNIT IIe-3

This unit consists of moderately well drained and somewhat poorly drained silty and loamy soils of the Ely, Judson, and Olmitz series. They are on alluvial fans or low foot slopes.

The soils in this unit have a thick, friable, silty clay loam or loam surface layer. They are dark colored to a depth of about 30 inches.

The available water capacity is high and permeability is moderate. The organic-matter content is high. Natural fertility is high.

Most areas of these soils are long and narrow and are not large. They are generally managed along with the adjoining soils. Corn and soybeans are the major crops if these soils are managed along with adjoining bottom-land soils. They are well suited to row crops if they are tilled on the contour and protected from runoff and sedimentation. In many places they are in permanent pasture along with steeper soils on side slopes that are not suited to cultivation. Oats and crops for rotation hay and pasture are also commonly grown.

The soils are subject to slight sheet erosion and to local flooding and gullying where runoff from adjacent sloping soils concentrates. In places sediments collect in areas of

these soils and are a hazard to young plants. In places there is slight wetness because of seepiness or local runoff, especially on the Ely soil.

Contour tillage and terraces on the adjacent uplands help to protect these soils from runoff and sediments. In places, diversion terraces at the base of the adjacent sloping soils on uplands are used to protect these soils. Where runoff concentrates, grassed waterways need to be constructed across areas of these soils. Corn responds well to additions of nitrogen and phosphorus fertilizer. Small amounts of potassium are generally beneficial, especially on the Olmitz soils. The soils are typically slightly acid or medium acid in the surface layer, and many areas need liming.

CAPABILITY UNIT IIs-1

The only soil in this unit is Wadena loam, moderately deep, 0 to 2 percent slopes. This soil is well drained and is underlain by sand and gravel. It is on stream benches.

The soil in this unit has a friable loam surface layer and is underlain at a depth of about 2½ feet by sand and gravel.

Available water capacity is reduced because of the shallowness to sand and gravel, and root growth is likely to be restricted. Permeability is moderate in the upper part and very rapid in the underlying sand and gravel. Organic-matter content is moderate. Natural fertility is about medium.

Most areas of this soil are cultivated. This soil is moderately suited to row crops, but because it is droughty it is not suited to high stand levels of corn or to heavy fertilization as are some of the other nearly level soils in the county. Corn and soybeans are the major crops, but oats and crops for rotation hay or pasture are also commonly grown.

This soil is droughty in most years and is very droughty in dry years. Corn responds well to applications of nitrogen and phosphorus fertilizers, but droughtiness limits response in some years. Potassium generally needs to be added. The soil is typically slightly acid in the surface layer, and some areas need liming.

CAPABILITY UNIT IIw-1

This unit consists of poorly drained, loamy soils of the Canisteo, Webster, and Harps series. They are mainly on uplands.

These soils have a loam or silty clay loam surface layer and a loam or clay loam subsoil. Available water capacity is high, and permeability is moderate or moderately slow. Organic-matter content is high. Natural fertility generally is medium to high, but it is low in the Harps soil.

Most areas of these soils are cultivated. They are well suited to row crops if adequately drained. Corn and soybeans are the major crops, but oats and hay are grown occasionally. If there is a large plant population, high rates of fertilization, and chemical control of weeds and insects, good vegetative cover can be grown.

The soils are wet unless artificially drained. A seasonal high water table generally is at a depth of about 4 feet or less. Runoff is slow, and some slightly depressed areas tend to pond during periods of heavy rainfall.

Tile drains are in most areas of these soils and work well. They are needed to permit field operations to be done at the proper time, to prevent crop damage because of excess wetness, and to improve root development and soil aeration. Satisfactory crop growth is difficult to obtain without artificial drainage. These soils are slow to warm in spring and tend to dry out cloddy and hard if worked when wet. They are commonly plowed in fall so that the freezing and thawing during winter will improve tilth and reduce the need for tillage early in spring. Corn responds well to additions of nitrogen and phosphorus fertilizer. Potassium needs to be added, especially on the Harps and Canisteo soils. Harps and Canisteo soils are low or very low in available phosphorus and potassium. Because the soils are neutral or have an excess of lime, additions of lime are not needed. Harps and Canisteo soils are high in lime content.

CAPABILITY UNIT IIw-2

This unit consists of nearly level, poorly drained, silty soils of the Colo, Vesser, Zook, and Calco series. They are on bottom lands and low stream benches.

Colo, Calco, and Zook soils have a silty clay loam surface layer. Vesser soils have silt loam surface and subsurface layers. Some of the soils receive sediments, and these soils are covered by 6 to 18 inches of light-colored silt loam overwash. Permeability is generally moderate or moderately slow, but it is slow in the heavy silty clay loam or silty clay layer below a depth of about 20 inches in Zook soils.

Available water capacity is high. The organic-matter content is high. Natural fertility is high.

Many areas of these soils are cultivated, but other areas are in permanent pasture. Corn and soybeans are the major crops. The soils are well suited to row crops if drainage is adequate and if the hazard of flooding is not severe.

These soils tend to be wet unless artificially drained. Some areas are subject to flooding, but flooding commonly occurs early in spring or is of short duration. Areas in depressions tend to pond after floods. Vesser soils generally flood less frequently than other soils in this unit.

Tile works well in most areas of these soils if suitable outlets are available. In Zook soils tiles need to be spaced closer together than in the other soils. The soils in the unit tend to dry out cloddy and hard if worked when wet. They are commonly plowed in fall so that the freezing and thawing during winter will improve tilth and reduce the need for tillage early in spring. In some areas protection from flooding is beneficial. In some places, diversion terraces are placed upslope to prevent runoff from uplands from flowing across areas of these soils. Grassed waterways are used in drainageways to remove excess water. Surface drains can be used in some places to reduce wetness and ponding in depressed areas.

Corn responds well to additions of nitrogen and phosphorus fertilizer. Phosphorus and potassium are especially likely to be lacking in the Calco soils. Vesser soils are the most likely to need liming. Colo and Zook soils seldom need lime in large amounts. Calco soils have carbonates and do not need liming.

CAPABILITY UNIT IIw-3

The unit consists of soils of the Colo series and Colo-Judson and Colo-Spillville complexes. Colo soils are poorly drained. Judson and Spillville soils are somewhat

poorly drained and moderately well drained and are on foot slopes. Slopes range from 2 to 5 percent. The Colo-Judson and Colo-Spillville complexes occupy drainageways and narrow stream valleys. Colo soils are on alluvial fans or low foot slopes that grade to bottom lands.

Colo soils are deep, dark colored, and silty clay loam in texture. One Colo soil is covered by 8 to 18 inches of light-colored silt loam overwash. The Judson soils in the Colo-Judson complex are silty clay loam in the thick surface layer and in the upper part of the subsoil. Spillville soils are loam in texture.

The available water capacity is high. Permeability is moderately slow or moderate. The organic-matter content and natural fertility are high.

Most areas of the Colo soils are cultivated. Many areas of the Colo-Judson or Colo-Spillville complexes are associated with steep soils and are in permanent pasture. The soils are well suited to row crops if drainage is adequate and the hazard of flooding is not severe. Corn and soybeans are the major crops.

These soils are typically wet because of seepage, a high water table, or flooding. Colo silt loam, overwash, is subject to runoff flowing across it from adjacent uplands and to deposition of lighter colored sediments. In places this runoff causes gullying. Tile drains are used to reduce wetness on these soils, but many areas are farmed without additional drainage. In places, diversions are used to prevent runoff from flowing across these areas and causing deposition. Surface runoff causes slight erosion on foot slopes, but deposition is about equal to the amount that is eroded. Most areas are tilled on the contour or across the slope.

These soils generally have good tilth, but if worked when wet they tend to dry out cloddy and hard. Corn responds well to additions of nitrogen and phosphorus fertilizer. Small amounts of potassium are generally beneficial. These soils seldom need large additions of lime.

CAPABILITY UNIT IIIe-1

This unit consists of moderately well drained and well drained, silty soils of the Clinton, Ladoga, Marshall, and Sharpsburg series. They are on side slopes on uplands. Also included is a Judson soil on foot slopes. Slopes range from 5 to 9 percent.

Soils in this unit have a friable silt loam and silty clay loam surface layer and, generally, a silty clay loam subsoil.

The available water capacity is high. Permeability is moderate or moderately slow. The organic-matter content is typically low in the moderately eroded Clinton, Ladoga, and Sharpsburg soils and medium in most of the other soils in the unit. It is high in the Judson soil. Natural fertility is low in the Clinton soil to moderate or high in other soils in the unit.

Most areas of these soils are cultivated. The soils are moderately well suited to row crops if erosion is controlled. Corn, soybeans, oats, and crops for rotation hay and pasture are grown. Some areas associated with steeper soils are in permanent pasture.

All of the soils are subject to erosion if row crops are grown. In places runoff from upslope concentrates and causes gullying in the Judson soil. The other soils are also subject to gullying in places. In some places soil tilth is poor.

Terraces and contour tillage are used to control runoff and erosion. In places gullies need shaping before terraces are constructed, and in others grassed waterways are needed. Diversion terraces at the base of some upland slopes are used to divert runoff from the Judson soil and prevent sheet erosion and gullying. Corn responds well to additions of nitrogen and phosphorus fertilizer. Small amounts of potassium are generally beneficial. Other crops generally respond well to applications of needed fertilizers. The soils are slightly acid to strongly acid in the surface layer, and many areas need liming.

CAPABILITY UNIT IIIe-2

This unit consists of moderately well drained and well drained, silty soils of the Clinton, Ladoga, Marshall, and Sharpsburg series. Slopes are 9 to 14 percent. These soils are on side slopes on uplands.

The soils in this unit have a friable silt loam and silty clay loam surface layer and mainly have a silty clay loam subsoil.

Available water capacity is high, and permeability is moderate or moderately slow. The organic-matter content is typically low or moderate. Natural fertility is low to medium.

Most areas of these soils are cultivated, but some areas associated with steeper soils are in permanent pasture. These soils are moderately well suited to row crops if erosion is controlled. Corn, oats, and crops for rotation hay and pasture are grown. Soybeans are generally not planted on these sloping soils.

These soils are subject to severe erosion. Gullies have formed in places. In many places tilth is poor.

Terraces, contour tillage, and shaping and seeding existing gullies for grassed waterways are practices that are used to control erosion (fig. 11). Additions of organic matter in the form of green manure, crop residue, and barnyard manure help to prevent erosion and to improve tilth.

Corn responds well to additions of nitrogen and phosphorus fertilizer. Small amounts of potassium are generally beneficial. Legumes and other crops respond well to additions of phosphorus and other fertilizer. These soils are slightly acid to medium acid in the surface layer, and many areas need liming.

CAPABILITY UNIT IIIe-3

This unit consists mainly of well drained and moderately well drained, loamy soils of the Clarion, Lester, Olmitz, Shelby, Storden, and Wadena series. Slopes range from 5 to 9 percent. Also in the unit is the Dickinson-Sharpsburg complex. Sharpsburg soils are silty and moderately well drained; Dickinson soils are loamy and somewhat excessively drained and well drained. The Wadena soil in this unit ranges up to 14 percent slopes. These soils are on uplands and stream benches.

These soils generally have a loam or clay loam surface layer, but the Sharpsburg soil is silty clay loam and the Dickinson soil is fine sandy loam. Wadena soils have sand and gravel in the substratum at a depth of about 24 to 40 inches.

Available water capacity generally is high, but it is low in the Dickinson soil and moderate or low in the Wadena soil, depending on depth to sand and gravel. Permeability is generally moderate or moderately slow,

Figure 11.—**Grassed back-slope terraces and waterways. Sharpsburg soils are upslope from terraces; Shelby soils are downslope.**

but it is moderately rapid or rapid in the Dickinson soil. Permeability is very rapid in the substratum of the Wadena soils. Organic-matter content is generally low to moderate, but it is low in the Storden soil and high in the Olmitz soil. Natural fertility is generally medium to high, but it is low in the Storden soil.

Most areas of these soils are cultivated. The soils are moderately well suited to row crops if erosion is controlled. Corn, soybeans, oats, and crops for rotation hay or pasture are grown.

Most of the soils are moderately eroded and are subject to further erosion if not protected by vegetation or conservation practices. The Dickinson soil and the Wadena soils, especially the moderately deep ones, are droughty. Gullies have formed in a few places.

Terracing, contour tillage, and shaping and seeding existing gullies for waterways are practices that are used to control erosion. On the Wadena and Dickinson soils, contour tillage is generally a better way to control erosion than terracing, because these soils are underlain by sand or gravel and terracing reduces available moisture capacity and productivity. Tilth is generally fairly good, but additions of organic matter in the form of green manure, crop residue, and barnyard manure help to prevent erosion and maintain or improve tilth. Corn responds well to additions of nitrogen and phosphorus fertilizer. Some potassium is generally needed. Other crops also respond well to needed fertilizer. The soils range from medium acid to mildly alkaline in the surface layer, and soil tests are needed to determine the need for lime.

CAPABILITY UNIT IIIe-4

This unit consists of mainly well drained and moderately well drained, loamy soils of the Clarion, Lester, Shelby, and Storden series. Slopes range from 9 to 14 percent. The Dickinson-Sharpsburg complex is also in this unit. Sharpsburg soils are silty; Dickinson soils are loamy. The soils are on uplands and stream benches.

The Clarion, Lester, Shelby, and Storden soils have a loam or clay loam surface layer. The surface layer of the Sharpsburg soil is silty clay loam and that of the Dickinson soil is fine sandy loam.

The available water capacity is generally high, but it is low in the Dickinson soil. Permeability is generally moderate or moderately slow, but it is moderately rapid or rapid in the Dickinson soil. The organic-matter content is generally low to moderate, but it is low in the Storden soil. Natural fertility is generally medium to high, but it is low in the Storden soil.

Most areas of these soils are cultivated. The soils are moderately well suited to row crops if erosion is controlled. Corn, oats, and crops for rotation hay and pasture are grown.

All the soils are moderately eroded and are subject to further erosion if not protected by vegetation or conservation practices. Gullies have formed in a few places. The Dickinson soils are droughty. Terracing, contour tillage, and shaping and seeding existing gullies for waterways are practices used to control erosion. Tilth is generally fairly good, but additions of organic matter in the form of green manure, crop residue, and barnyard manure help to prevent erosion and maintain or improve tilth. Corn responds well to additions of nitrogen and phosphorus fertilizer. Some potassium is generally beneficial. Other crops also respond well to needed fertilizer. The soils range from medium acid to moderately alkaline in the surface layer, and soil tests are needed to determine the need for lime.

CAPABILITY UNIT IIIw-1

This unit consists of very poorly drained and poorly drained soils of the Okoboji and Humeston series. They are in shallow depressions on uplands and on bottom lands.

The Okoboji soil has a silty clay loam surface layer and subsoil. The Humeston soil has a silt loam surface layer and subsurface layer and a silty clay loam subsoil.

Permeability is slow or very slow in the Humeston soil and moderately slow in the Okoboji soil. Natural fertility is high.

Most areas of these soils are small and are farmed along with the surrounding soils. These soils are moderately well suited to row crops if adequately drained. Corn and soybeans are the major crops, but oats and crops for rotation hay and pasture are also grown.

These soils are very wet, and some areas tend to pond in spring or during heavy rains. Crops drown out in places. The soils warm up slowly in spring, and tillage operations are delayed in these and the surrounding soils in many places. Some areas of Humeston soils are subject to flooding. Tile drains work well in the Okoboji soil, but surface drains are also used in some places. Tile drains do not work so well in Humeston soils because of the heavy silty clay loam subsoil, but surface drains are also used in some places.

Corn responds well to additions of nitrogen and phosphorus fertilizer, and some potassium is generally needed. Other crops also respond well to needed fertilizer. The Okoboji soil does not need liming. The Humeston soil is typically acid in the surface layer, and many areas need additions of lime.

CAPABILITY UNIT IVe-1

This unit consists of moderately well drained to poorly drained soils of the Adair, Clarinda, Lamoni, Clearfield, and Gara series and in the Shelby-Adair complex. Slopes range from 9 to 14 percent.

Soils in this unit have a silty clay loam or clay loam surface layer. The Adair, Lamoni, and Clarinda soils have a very firm clayey subsoil.

The available water capacity is generally high, but it is somewhat lower in the Clarinda soil. Permeability is moderately slow or slow in the Adair, Lamoni, Gara, and Shelby soils, but it is very slow in the clay layer of the Clearfield soils that is at a depth of 3 to 6 feet. It is also very slow in the subsoil of the Clarinda soil. The organic-matter content is typically moderate to low. Natural fertility is low to medium.

Many areas of these soils are in narrow bands in cultivated fields along with soils better suited to cultivation. Other areas are in permanent pasture. These soils are not well suited to row crops. They are better suited to hay or pasture.

These soils are moderately eroded, and the hazard of further erosion is severe, especially in cultivated areas. Most of the soils do not absorb water readily, and the amount of water that runs off is high. The Adair, Clarinda, and Clearfield soils are wet and seepy in spring and during periods of above average rainfall. In many cultivated fields, tilth is poor. Some areas have uncrossable gullies.

In places it is possible to place tile drains in the loess soils upslope to reduce wetness and make occasional row croping more practical. Tile drains do not work well when placed directly in the clayey soils of this unit. The Gara soil is not seepy, as are other soils in the unit, and it is better suited to cultivation. Terraces are not generally built in these clayey soils because the clayey subsoil is very hard to vegetate when exposed in terrace channels. Terraces are usually built in soils upslope or downslope that are more suitable for terrace construction.

Establishing stands of forage crops is commonly difficult because of wetness and the difficulty in establishing a good seedbed. Some soils, especially those of the Clarinda series, are too wet for alfalfa. Birdsfoot trefoil and white and alsike clover are more tolerant of wetness than alfalfa. They are often used with bluegrass in pasture. Controlling grazing is important in newly seeded pastures. If new seedings are grazed when wet, they are subject to damage. Crops generally respond well to additions of needed fertilizer. Nitrogen and phosphorus are generally low or very low, and available potassium is generally low or medium. The soils are acid in the surface layer, and many areas need liming.

CAPABILITY UNIT IVe-2

This unit consists of well drained or moderately well drained, silty and loamy soils of the Clinton, Ladoga, Sharpsburg, Shelby, Storden, and Clarion series. They are mainly on side slopes of 14 to 18 percent on uplands. The Clinton soil has slopes of 9 to 14 percent.

These soils have a silt loam or loam surface layer. The available water capacity is high. Permeability is moderately slow to moderate. The organic-matter content is low. Natural fertility is low to medium.

Many areas of these soils have been or are cultivated. Some areas are in permanent pasture because they are associated with soils not suited to cultivation. Some

formerly cultivated areas have been allowed to revert to permanent bluegrass pasture. These soils are not well suited to row crops. They are better suited to hay and pasture. When stands of hay or pasture become poor, after about 5 years or more, many farmers grow a crop of corn on the contour.

All of the soils are moderately eroded, except the Clinton soil, which is severely eroded. The hazard of further erosion is very severe if these soils are cultivated. The moisture supply is seldom at capacity because a considerable amount of the rain that falls runs off. Tilth is poor in many cultivated areas, especially in the Ladoga and Shelby soils. In some places the upper edge of areas of Shelby soils are seepy and wet in spring and during periods of very high rainfall. Gullies have formed in some places.

Some of these soils are terraced, but even if terraced, they are only suited to an occasional row crop. In places gullies need shaping and seeding. Corn responds well to additions of nitrogen and phosphorus fertilizer. Small amounts of potassium are generally beneficial, especially on the Shelby, Storden, and Clarion soils. Mixtures of grasses and legumes respond very well to phosphorus. The soils range from moderately alkaline to medium acid in the surface layer. The need for lime and fertilizers should be determined by soil tests.

CAPABILITY UNIT IVw-1

The only soil in this unit is Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded. It is poorly drained and is on side slopes on uplands.

This soil has a very firm, clayey subsoil. Permeability is very slow. Organic-matter content is typically low. Natural fertility is low.

This soil is poorly suited to row crops. It is better suited to hay or pasture, but some corn, soybeans, and small grain crops are grown. Some areas remain in permanent pasture.

This soil is moderately eroded and is susceptible to further erosion if cultivated, because water intake is slow and much water runs off. This soil is wet and seepy in spring and during periods of above normal rainfall. Tilth is poor in many areas, and tillage is difficult. Gullies have formed in some areas.

It is difficult to perform planting operations on time. Row crops are often stunted and slow to mature. If the wetness is reduced by placing interceptor tile drains in the loess soils upslope and the soil is tilled on the contour, an occasional row crop can be grown. Tile lines placed directly in the very slowly permeable Clarinda soil do not work well. Hay and pasture plants tolerant to wetness are especially suitable. Erosion is controlled by terracing areas above and below this soil. Terraces are difficult to construct and vegetate in the clayey soils. Legumes and grasses planted for hay or pasture respond well to additions of lime and phosphorus fertilizer. The response of row crops to fertilizer is typically poor. The soil is slightly acid or medium acid in the surface layer, and many areas need liming.

CAPABILITY UNIT Vw-1

This unit consists of Colo silt loam, channeled; Colo-Spillville complex, channeled; Nodaway silt loam, channeled; and Olmitz-Colo complex; channeled; and Alluvial land. These are mainly nearly level and slightly undulating soils on bottom lands. Wetness is a hazard. Most areas have a seasonal high water table; some are frequently flooded; others are cut up by old meandering stream channels.

Most areas in this unit are in permanent pasture, some have growths of trees and brush, and a few are cultivated.

Planning soil use is a matter of judgment and experience in the areas involved. Some areas have good potential for cultivated crops if streams can be straightened or levees constructed to protect them from flooding. In some areas trees and undergrowth need to be removed, channels filled, and artificial drainage provided. Areas not protected and drained generally are left in pasture. Some pastures can be improved by additions of fertilizer and by planting more productive grasses and legumes. Many areas are suitable for trees. In places use of these areas for trees for timber products, for recreational uses, or for wildlife habitat should be considered, if there is a good stand of trees and the area is not accessible for other uses. Generally, however, trees growing in these areas are of low value. The response of crops to fertilizers is variable. Many areas need liming.

CAPABILITY UNIT VIe-1

This unit consists of moderately well drained to somewhat poorly drained, loamy soils of the Adair and Lamoni series and of the Gara-Armstrong and Shelby-Adair complexes. The soils are on uplands. Slopes are mainly 14 to 18 percent. In one severely eroded area of Shelby-Adair complex, slopes are 9 to 14 percent.

Soils in this unit have a friable to firm, clay loam, silty clay loam, or loam surface layer. The Adair, Armstrong, and Lamoni soils have a very firm or firm clayey subsoil. Shelby and Gara soils have a clay loam subsoil.

The available water capacity is high. Permeability is moderately slow to very slow in the subsoil. The organic-matter content is typically low. Natural fertility is low.

Some areas of these soils have been or are cultivated along with surrounding soils. Most areas are in permanent pasture. Some have scattered trees and brush. Slope and the hazard of erosion make these soils unsuited to cultivated crops. They are better suited to hay or pasture.

These soils are moderately or severely eroded, and the hazard of further erosion is severe if they are not protected by a vegetative cover because water runs off readily. In many places these soils are wet and seepy in spring and during periods of above normal rainfall. The soils of the Gara-Armstrong and Shelby-Adair complexes are not so wet as the other soils in this unit. Tilth is generally poor.

Machinery can be used in many areas to prepare seedbeds for suitable hay and pasture plants, to renovate existing areas in permanent pasture, or to reseed pastures. In some places, trees and brush can be removed and more productive pasture established. Seedings are difficult to establish in some places because the soils are wet and in poor tilth. Gullies that have formed need to be filled and seeded to grass for waterways. Some wooded areas can be protected from grazing and managed as woodland. Some inaccessible areas that are of little value for other uses can be used for wildlife habitat. Controlled grazing is an important management practice in increas-

ing the production of pastures and is especially important on new seedings. If new seedings are grazed when very wet, they are susceptible to damage. These soils provide suitable sites for ponds that supply water for livestock.

Pasture plants generally respond well to additions of fertilizer. Available nitrogen is generally low, available phosphorus is generally low or very low, and available potassium is generally low or medium. The soils are acid, and many areas need liming.

CAPABILITY UNIT VIe-2

This unit consists of moderately well drained and well drained, loamy soils of the Gara, Lindley, Shelby, and Storden series. They are on uplands. Slopes range from 14 to 25 percent.

Soils in this unit have a friable or firm, clay loam or loam surface layer.

The available water capacity is high. Permeability is moderately slow or moderate. The organic-matter content is low. Natural fertility is low to medium.

Most areas of these soils are in permanent pasture. Many areas of the Gara soil and most areas of the Lindley soil contain trees and brush, but they are generally managed as pasture. Because of slope, low productivity, and the hazard of severe erosion, these soils are unsuited to cultivation. They are suited to pasture.

All of these soils are moderately or severely eroded. Gullies have formed in many places. Water runs off these soils rapidly, and the amount of available moisture for use is commonly low.

Farm machinery can be used in some areas to prepare seedbeds for suitable hay and pasture plants, to renovate existing areas in permanent pasture, or to reseed pasture. In some places scrub trees and brush can be removed and more productive pasture established. Controlling grazing and undesirable vegetation also improves the productivity of pastures. Gullies that have formed need to be shaped and seeded to grass for waterways. Some wooded areas can be protected from grazing and managed as woodland. Some inaccessible areas that are of little value for other uses can be used for wildlife habitat. These soils are commonly suitable for ponds for supplying water for livestock.

Pasture plants generally respond well to additions of fertilizer. Available nitrogen and phosphorus are generally very low or low, and available potassium is generally low or medium. The soils range from slightly acid to mildly alkaline in the surface layer. Lime needs should be determined by soil tests.

CAPABILITY UNIT VIs-1

This unit consists of excessively drained to well-drained, sandy and loamy soils of the Hesch, Montieth, and Salida series.

These soils have a loam, loamy sand, or sandy loam surface layer. Hesch and Montieth soils formed in material weathered from sandstone and have a sandy loam and loamy sand subsoil. The Salida soil is gravelly throughout the profile. The available moisture capacity of these soils is low to very low. Permeability is moderately rapid to very rapid. The organic-matter content is typically low. Natural fertility is low.

Most areas of these soils are in pasture. Some areas have been cultivated in the past. They are not suited to row crops. They are suited to permanent vegetation and can be used for hay or pasture, but pasture is generally a better use than hay.

These soils absorb water readily, but some erosion occurs if rains are heavy and vegetation is sparse. These soils are droughty. Farm machinery can be used in many areas to renovate permanent pasture, but some areas are rough and gullied. Drought-resistant plants should be planted on these soils. The Salida soil is so gravelly in places that tillage is not practical.

Additions of phosphorus and potassium are especially beneficial in establishing grasses and legumes. Because of droughtiness, large amounts are not generally applied. Controlling grazing to maintain a good vegetative cover is important in controlling erosion and gullying. Small inaccessible areas can be used for wildlife habitat if shrubs and other vegetation are established. The Hesch and Montieth soils are acid and need liming. The Salida soil has carbonates at or near the surface and does not need additional lime.

CAPABILITY UNIT VIIe-1

This unit consists of soils of the Adair, Clanton, Gara, Gosport, and Lindley series and of the Shelby-Adair complex. Slopes range from 14 to 40 percent. These soils vary considerably in the textures of the surface layer and subsoil. The surface layer is generally clay loam, loam, or silt loam, and the subsoil ranges from clay loam to silty clay and clay.

The available water capacity is moderate or high. Permeability ranges from moderately slow to very slow. Natural fertility is low.

Most areas of these soils are in permanent pasture or woodland. Most wooded areas are managed as pasture. A few areas are or have been cultivated. These soils are not suited to cultivation. Some areas are poorly suited to pasture. Many areas are better suited to woodland or wildlife habitat than to other uses. Many areas are large and can be managed separately.

Runoff is rapid, and the amount of water available for use is not generally at capacity. The Adair soil and areas of the Shelby-Adair complex are seasonally wet because of seepage. The steep slope, rough topography, and gullies make the use of farm machinery hazardous in most places. In most areas renovation of pasture is not practical, but renovation is possible on some of the more gently sloping soils. Control of grazing is an important management practice. Many wooded areas could be managed more profitably for timber products than as pasture. Areas managed as woodland should be protected from grazing.

CAPABILITY UNIT VIIw-1

Only Marsh is in this unit. Marsh consists of depressional areas that are covered by water much of the year. During periods of low rainfall the area covered by water disappears or decreases in size, and swamp vegetation grows around the perimeter of the areas.

The basin of the depressions contains dark, silty alluvium. Near the edges of the depressions, 6 to 10 inches of muck or partly decayed plant residue makes up the surface layer.

These areas are unfit for most farm uses. They are well suited to wildlife habitat. Waterfowl, muskrats, and other

wildlife find food and nesting places in or around the edges of Marsh.

Some areas have been set aside as game refuges and public hunting grounds. In some areas controls have been provided to maintain a more constant water level. Other areas have potential for this kind of habitat improvement.

CAPABILITY UNIT VIIs-1

This unit consists of excessively drained to well drained, sandy and loamy soils of the Hesch and Montieth series. Slopes are mainly 14 to 30 percent. A few areas of Hesch soils slope as little as 9 percent.

These soils have a loam, sandy loam, or loamy sand surface layer and a sandy or loamy subsoil.

The available water capacity is low or very low. Permeability is moderately rapid to very rapid. The organic-matter content and natural fertility are low.

Most areas of these soils are in permanent pasture. Some of the pastures contain scrub timber and brush. These soils are not suited to cultivation. They are suited to permanent pasture, but low fertility and droughtiness limit productivity. Some pastures can be made more productive by clearing brush and trees. Some areas should be left wooded and managed as wildlife habitat.

These soils are subject to erosion, especially during periods of heavy rainfall and when vegetation is sparse. These soils are very droughty, and plant growth is generally poor. Farm machinery can be operated on some areas to renovate pastures, but establishing a good stand is difficult. Plants need to be drought-resistant. The soils are low in fertility, but they are so droughty that only small amounts of fertilizer are generally profitable. Controlling grazing to maintain a good vegetative cover is important in controlling erosion and gullying. It also increases the productivity of the pastures.

Yield predictions

In table 2 the average acre yields of the principal crops that can be expected under a high level of management are predicted for soils of the county. Under this level of management, seedbed preparation, planting, and tillage practices provide for adequate stands of adapted varieties; erosion is controlled; the organic-matter content and soil tilth are maintained; the level of fertility for each crop is maintained as indicated by soil tests and field trials; the water level in wet soils is controlled; weed and pest control is excellent; and farm operations are timely.

Sources of yield information were data from the Federal census, the Iowa farm census, data from experimental farms and cooperative experiments with farmers, and from on-farm experience by soil scientists, extension workers, and others.

The yield predictions serve as guides. They are approximate values only and should be so considered. Of more value than actual yield figures to many users are the comparative yields of various soils. These relationships are likely to remain constant over a period of years. On the other hand, actual yields have been increasing in recent years. If they continue to increase as expected, predicted yields in this table will soon be too low.

Woodland, Wildlife, and Recreation

Approximately 38,000 acres, or about 10 percent of the county, is wooded. At the time of settlement about 44,000 acres were in timber (*5*). This area was mainly in the Gara-Lindley and Sharpsburg-Ladoga-Shelby associations, but some areas were in parts of other associations.

Some native timber is being cleared, but not extensively. Large wooded areas are now mostly on steep soils adjacent to major streams and to narrow stream bottom lands.

The uses of the soils for woodland, wildlife, and recreation are related in many ways. This section is of special interest to those who enjoy the outdoors and are concerned with the preservation of areas not suited to crops or pasture but that are suited to woodland, wildlife habitat, or recreational uses.

Use of the soils for woodland

Most of the natural forest growth is on the steeper soils adjacent to streams in soil associations 4 and 6. Some areas are in the bottom lands and in other associations. A few farms have small woodlots. The planting of trees and shrubs is common around farmsteads for windbreaks or landscaping. As the size of individual farms increases, more soil is converted to cropland or pasture. This generally involves some clearing of trees.

Most of the existing wooded areas in the county are used for grazing and timbered pasture. Only a few acres are managed only as woodland. Very steep areas produce little feed. If these areas adjoin pastures, they provide little more than shade for livestock and habitat for wildlife.

The acreage of woodland has not changed significantly in recent years, but some clearing and conversion to cropland or pasture are carried on each year. The more recent conversions are mainly on ridgetops, in moderately sloping areas on short side slopes, and on river bottoms. The Clinton, Ladoga, and Gara soils on uplands and the Kennebec, Nodaway, and Spillville soils in bottom lands generally are cleared. These soils generally are better suited to crops or pasture than the other wooded soils.

The soils of Guthrie County have been placed in nine woodland suitability groups to assist owners of woodland in planning the use of the soils. Each group includes soils that have about the same available water capacity and other characteristics that influence the growth of trees. These soils also have similar limitations and are subject to the same hazards when used for trees. All the soils in one group, therefore, support similar kinds of trees, have about the same potential productivity, and require similar kinds of management.

Each group is briefly described, and the main characteristics of the soils, existing conditions, and hazards that affect woodland production are given. Some suitable species for the group are also listed. This includes species suitable for veneer, lumber, windbreaks, and Christmas trees, as well as shrubs and trees suitable for wildlife habitat. Of these species listed as suitable for windbreaks, the conifers are especially suited to farmstead wind-

TABLE 2.—*Predicted average yields per acre of principal crops under a high level of management*

[Dashes indicate the soil is not suited to the crop or that the crop is ordinarily not grown on the soil]

Mapping unit	Corn	Soy-beans	Oats	Alfalfa and grass hay	Pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*Animal-unit-days* [1]
Adair clay loam, 9 to 14 percent slopes, moderately eroded	----	----	----	2.0	100
Adair clay loam, 14 to 18 percent slopes, moderately eroded	----	----	----	1.0	50
Adair soils, 14 to 18 percent slopes, severely eroded	----	----	----	1.0	50
Alluvial land	----	----	----	----	[2] 30
Calco silty clay loam	99	38	70	4.5	225
Canisteo silty clay loam	105	40	74	4.5	225
Clanton silt loam, 18 to 30 percent slopes	----	----	----	----	[2] 30
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	55	21	39	2.8	140
Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	----	----	----	2.0	100
Clarion loam, 2 to 5 percent slopes	110	42	77	4.5	225
Clarion loam, 2 to 5 percent slopes, moderately eroded	107	41	75	4.5	225
Clarion loam, 5 to 9 percent slopes	105	40	74	4.5	225
Clarion loam, 5 to 9 percent slopes, moderately eroded	102	39	72	4.0	200
Clarion loam, 9 to 14 percent slopes, moderately eroded	93	35	65	3.5	175
Clarion loam, 14 to 18 percent slopes	81	----	57	3.0	150
Clearfield silty clay loam, 9 to 14 percent slopes, moderately eroded	79	30	55	3.0	150
Clinton silt loam, 2 to 5 percent slopes	107	41	75	4.2	210
Clinton silt loam, 5 to 9 percent slopes, moderately eroded	99	38	69	4.0	200
Clinton silt loam, 9 to 14 percent slopes, moderately eroded	90	34	63	3.8	190
Clinton soils, 9 to 14 percent slopes, severely eroded	84	32	59	3.5	175
Colo silty clay loam, 0 to 2 percent slopes	104	40	73	5.0	250
Colo silty clay loam, 2 to 5 percent slopes	102	39	72	4.5	225
Colo silt loam, channeled, 0 to 2 percent slopes	----	----	----	----	[2] 90
Colo silt loam, overwash, 0 to 2 percent slopes	104	40	73	5.0	250
Colo silt loam, overwash, 2 to 5 percent slopes	102	39	72	4.5	225
Colo-Judson complex, 2 to 5 percent slopes	102	39	72	4.0	200
Colo-Spillville complex, 2 to 5 percent slopes	102	39	72	4.0	200
Colo-Spillville complex, channeled, 2 to 5 percent slopes	----	----	----	----	[2] 90
Cylinder loam	103	39	72	3.0	150
Dickinson-Sharpsburg complex, 5 to 9 percent slopes, moderately eroded	80	30	56	3.0	150
Dickinson-Sharpsburg complex, 9 to 14 percent slopes, moderately eroded	73	28	51	2.7	135
Ely silty clay loam, 2 to 5 percent slopes	124	47	87	5.0	250
Gara loam, 9 to 14 percent slopes, moderately eroded	75	28	53	3.0	150
Gara loam, 14 to 18 percent slopes, moderately eroded	----	----	----	2.5	125
Gara loam, 18 to 25 percent slopes, moderately eroded	----	----	----	1.5	75
Gara loam, 25 to 40 percent slopes, moderately eroded	----	----	----	----	[2] 50
Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded	----	----	----	1.5	75
Gosport silt loam, 9 to 18 percent slopes, moderately eroded	----	----	----	1.5	75
Gosport silt loam, 18 to 30 percent slopes, moderately eroded	----	----	----	----	[2] 35
Harps loam	95	36	62	4.0	200
Hesch sandy loam, 9 to 18 percent slopes	----	----	----	1.0	50
Hesch loam, 9 to 14 percent slopes	----	----	----	1.3	65
Hesch loam, 14 to 18 percent slopes	----	----	----	----	40
Humeston silt loam	88	23	62	3.0	150
Judson silty clay loam, 2 to 5 percent slopes	114	43	80	5.0	250
Judson silty clay loam, 5 to 9 percent slopes	109	41	72	4.5	225
Kennebec silt loam	118	45	83	5.0	250
Ladoga silt loam, 0 to 2 percent slopes	118	45	83	4.8	240
Ladoga silt loam, 2 to 5 percent slopes	113	43	79	4.5	225
Ladoga silt loam, 5 to 9 percent slopes	108	41	76	4.2	210
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	105	40	74	4.0	200
Ladoga silt loam, 9 to 14 percent slopes	99	38	69	3.5	175
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	96	36	67	3.5	175
Ladoga silt loam, 14 to 18 percent slopes, moderately eroded	81	----	57	3.2	160
Ladoga silt loam, benches, 2 to 5 percent slopes	113	43	79	4.5	225
Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	55	21	39	2.0	100
Lamoni silty clay loam, 14 to 18 percent slopes, moderately eroded	----	----	35	1.5	75
Lester loam, 2 to 5 percent slopes	104	40	73	4.5	225
Lester loam, 5 to 9 percent slopes, moderately eroded	92	35	64	4.0	200
Lester loam, 9 to 14 percent slopes, moderately eroded	83	32	58	3.5	175
Lindley loam, 14 to 18 percent slopes, moderately eroded	----	----	----	1.8	90
Lindley loam, 18 to 25 percent slopes, moderately eroded	----	----	----	1.5	75
Lindley loam, 25 to 40 percent slopes, moderately eroded	----	----	----	----	[2] 40
Lindley soils, 18 to 25 percent slopes, severely eroded	----	----	----	1.5	75
Macksburg silty clay loam	121	46	85	5.0	250
Marsh	----	----	----	----	----

TABLE 2.—*Predicted average yields per acre of principal crops under a high level of management*—Continued

Mapping unit	Corn	Soy-beans	Oats	Alfalfa and grass hay	Pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*Animal-unit-days* [1]
Marshall silty clay loam, 2 to 5 percent slopes	107	44	75	5.0	250
Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	99	38	69	4.5	225
Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	90	34	63	4.0	200
Marshall silty clay loam, benches, 2 to 5 percent slopes	107	41	75	5.0	250
Montieth loamy sand, 9 to 14 percent slopes				1.0	50
Montieth loamy sand, 14 to 18 percent slopes					[2] 30
Montieth loamy sand, 18 to 30 percent slopes					[2] 30
Nevin silty clay loam	114	43	80	4.5	225
Nicollet loam, 1 to 3 percent slopes	118	45	83	4.5	225
Nodaway silt loam	108	41	76	4.5	225
Nodaway silt loam, channeled					[2] 90
Okoboji silty clay loam	86	33	60	4.0	200
Olmitz loam, 2 to 5 percent slopes	100	38	70	4.0	200
Olmitz loam, 5 to 9 percent slopes	95	36	67	4.0	200
Olmitz-Colo complex, channeled, 2 to 7 percent slopes					[2] 110
Salida sandy loam, 7 to 14 percent slopes, moderately eroded				1.0	50
Sharpsburg silty clay loam, 0 to 2 percent slopes	115	44	81	4.8	240
Sharpsburg silty clay loam, 2 to 5 percent slopes	113	43	79	4.6	230
Sharpsburg silty clay loam, 5 to 9 percent slopes	108	41	76	4.4	220
Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded	105	40	74	4.4	220
Sharpsburg silty clay loam, 9 to 14 percent slopes	99	38	69	4.2	210
Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded	96	36	62	3.6	180
Sharpsburg silty clay loam, 14 to 18 percent slopes, moderately eroded	81		57	3.0	150
Sharpsburg silty clay loam, benches, 2 to 5 percent slopes	113	43	79	4.8	240
Shelby loam, 2 to 5 percent slopes	98	37	69	3.7	185
Shelby loam, 5 to 9 percent slopes, moderately eroded	90	35	63	3.5	175
Shelby loam, 9 to 14 percent slopes, moderately eroded	81	31	57	3.0	150
Shelby loam, 14 to 18 percent slopes, moderately eroded	66		46	2.5	125
Shelby loam, 18 to 25 percent slopes, moderately eroded				1.5	75
Shelby soils, 14 to 18 percent slopes, severely eroded				2.0	100
Shelby soils, 18 to 25 percent slopes, severely eroded				1.3	65
Shelby-Adair complex, 9 to 14 percent slopes, moderately eroded	73	28	51	2.5	125
Shelby-Adair complex, 9 to 14 percent slopes, severely eroded				2.0	100
Shelby-Adair complex, 14 to 18 percent slopes, moderately eroded				1.8	90
Shelby-Adair complex, 14 to 18 percent slopes, severely eroded				1.5	75
Spillville loam, 1 to 3 percent slopes	122	46	85	4.5	225
Storden loam, 5 to 9 percent slopes, moderately eroded	92	35	64	3.0	150
Storden loam, 9 to 14 percent slopes, moderately eroded	83		58	3.0	150
Storden loam, 14 to 18 percent slopes, moderately eroded	68		35	2.5	125
Storden loam, 18 to 25 percent slopes, moderately eroded				1.5	75
Vesser silt loam, 0 to 2 percent slopes	95	36	67	4.0	200
Vesser silt loam, overwash, 0 to 2 percent slopes	95	36	67	4.0	200
Wadena loam, deep, 0 to 2 percent slopes	92	35	64	3.5	175
Wadena loam, deep, 2 to 5 percent slopes	90	34	63	3.5	175
Wadena loam, deep, 5 to 14 percent slopes	82	31	57	3.3	165
Wadena loam, moderately deep, 0 to 2 percent slopes	72	29	50	3.0	150
Wadena loam, moderately deep, 2 to 5 percent slopes	70	27	49	3.0	175
Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	62	24	43	2.5	125
Webster silty clay loam	110	42	77	4.5	225
Zook silt loam, overwash	98	37	69	4.0	200
Zook silty clay loam	96	36	67	4.0	200

[1] A term used to express the carrying capacity of pasture. It is the number of animal units carried per acre multiplied by the number of days the pasture is grazed during a single season without injury to the sod. Alfalfa and grass pasture is based on the assumption that one mature animal will consume 40 pounds of dry matter per pasture-day.

[2] Bluegrass.

breaks and the hardwoods are especially suited to field windbreaks. Elm is one of the most numerous and most common species of hardwood trees in the county. It is not listed as a recommended species because the Dutch Elm disease is rapidly killing existing stands. Many thousands of elms remain, but dead and drying trees present a management problem because they need to be removed.

For most of the groups, the site index ratings and annual growth in board feet (*27*) are given for suitable trees. The site index is the total height, in feet, of the dominant and codominant trees in the stand at 50 years of age. It indicates potential productivity.

Each woodland group is also rated for hazards that need to be considered in management.

Seedling mortality refers to the expected loss of naturally occurring or planted seedlings that results from

unfavorable soil characteristics. It is slight if no more than 25 percent of the seedlings die, moderate if 25 to 50 percent die, and severe if more than 50 percent die.

Plant competition refers to the amount of competition from undesirable species that invade a site when openings are made in the canopy. Competition is slight if unwanted plants do not prevent adequate regeneration or interfere with the early growth of seedlings, it is moderate if invaders delay but do not prevent the establishment of seedlings, and severe if unwanted plants prevent the growth of seedlings.

Equipment limitation refers to the characteristics of a soil that restrict or prohibit the use of common farm equipment. The limitation is slight if there is no restriction in the kind of equipment or the time of year when it is used; moderate if the use of equipment is somewhat restricted by slope, stoniness, seasonal wetness, or soil structure and stability; and severe if special equipment is needed and its use is severely restricted by one of the items listed for "moderate" or by safety in operation.

Erosion hazard refers to the expected erosion that results from cutting and removing trees. It is slight if potential erosion is unimportant; moderate if some practices, such as the use of diversion terraces, are needed to prevent accelerated erosion; and severe if intensive treatment is needed to control soil loss.

WOODLAND SUITABILITY GROUP 1

This group consists of nearly level to steep soils of the Dickinson-Sharpsburg complex and the Hesch, Montieth, Salida, and Wadena series. These soils are mainly coarse textured, moderately coarse textured, and medium textured in the surface layer and subsoil. Some are medium textured in the upper part and sandy or gravelly in the lower part. The Montieth soils are underlain by sandstone at a depth of 24 to 40 inches. The Salida soils are underlain by gravelly loamy sand at a depth of 8 to 14 inches. The Sharpsburg soils in the Dickinson-Sharpsburg complex have a deep, silty profile. Permeability is moderate to very rapid, except in the Sharpsburg soils where it is moderately slow. An inadequate supply of moisture is the chief limitation to tree growth.

The suitability rating of most of these soils is fair to good for hardwoods and good for conifers. Montieth and Salida soils, however, have a low or very low available water capacity and are rated poor for hardwoods and fair for conifers. Production of timber from existing stands is 150 to 199 board feet per acre per year. The average site index for upland hardwoods ranges from 45 to 65, and the estimated annual growth is 100 to 149 board feet. For Montieth and Salida soils, however, the average site index is less than 45, and the estimated annual growth is less than 100 board feet.

Plant competition is slight to moderate on these soils. The equipment limitation is slight on slopes of 0 to 18 percent and moderate to severe on steeper slopes. The hazard of erosion is slight to severe, depending on the slope.

Trees to favor in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Trees most suitable for openland, noncommercial plantings or plantings for wildlife or beautification are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir. In addition to these species, trees suitable for noncommercial interplanting in existing stands are walnut, green ash, hackberry, red oak, white oak, and basswood.

Species most suitable for windbreaks are the conifers, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir, and the hardwoods, Norway poplar, Siouxland poplar, robusta poplar, green ash, and hackberry. Honeysuckle is a suitable shrub.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 2

This group consists of well drained and moderately well drained, medium-textured to moderately fine textured, nearly level to moderately steep soils of the Clinton, Judson, Ladoga, Marshall, and Sharpsburg series. They are on uplands and benches. Slopes range from 0 to 18 percent. All of these soils formed in loess, except for Judson soils that formed in silty alluvium. Permeability is moderate to moderately slow. The available moisture capacity is high. The chief limitations to tree growth are plant competition and lack of sufficient moisture because of climate and runoff.

The suitability rating of these soils is excellent for hardwoods, conifers, and cottonwood trees. Production of timber from existing stands ranges from 250 to 300 or more board feet per acre per year. The average site index for upland hardwoods ranges from 76 to 85.

Seedling mortality is slight. Plant competition from grass or weeds or undesirable species is slight to severe, depending on competition from such grass as bromegrass. The equipment limitation is slight. The hazard of erosion is slight on most of the soils, but ranges to moderate on some of the steeper soils.

Trees to favor in existing hardwood stands are walnut, white oak, red oak, green ash, hard maple, basswood, and wild black cherry. Walnut should be favored in protected coves.

Trees most suitable for openland, noncommercial plantings or plantings for wildlife habitat or for beautification are eastern white pine, red pine, Norway spruce, Scotch pine, European larch, eastern redcedar, walnut, green ash, hackberry, and hard maple. In addition to these species, trees suitable for noncommercial interplanting in existing stands are red oak, white oak, and basswood. Walnut is planted in coves where Judson soils occur.

Species most suitable for windbreaks are the conifers, eastern white pine, red pine, Norway spruce, white spruce, and eastern redcedar, and the hardwoods, Norway poplar, robusta poplar, green ash, and hackberry.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 3

This group consists of well drained and moderately well drained, medium-textured and moderately fine textured soils of the Clarion, Gara, Lester, Lindley, Olmitz, Shelby, and Storden series. Also in the group are Gara-Armstrong, Shelby-Adair, and Olmitz-Colo complexes. Adair and Armstrong soils are moderately well drained to somewhat poorly drained and have a fine-textured

subsoil. The Colo soil is poorly drained and moderately fine textured throughout. The Storden soil is calcareous at or near the surface. Soils in this group are gently sloping to moderately steep. Slopes range from 2 to 18 percent. Permeability is moderately slow, but it is slow in the Adair soil. Available moisture capacity is high. The chief limitations to tree growth are plant competition and lack of sufficient moisture because of climate and runoff.

The suitability rating of these soils is good to very good for hardwoods, good for conifers, and very good for cottonwood trees. Production of timber from existing stands generally ranges from 150 to 250 board feet per acre per year, but it is less than 100 board feet on the Storden soil. The average site index for upland hardwoods generally ranges from 56 to 75, but it is less than 45 on the Storden soil.

Seedling mortality is slight. Plant competition from grass or weeds or undesirable species is slight to moderate, depending on competition from grasses, such as bromegrass. The equipment limitation is slight. The hazard of erosion is slight or moderate on most of the soils, but is moderate or severe on some of the steeper soils.

Trees to favor in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Trees most suitable for openland, noncommercial planting and plantings for wildlife habitat or for beautification are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, Douglas-fir, black walnut, green ash, and hackberry. In addition to these species, trees suitable for noncommercial interplanting in existing stands are red oak, white oak, and basswood.

Species most suitable for windbreaks are the conifers, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir, and the hardwoods, Norway poplar, Siouxland poplar, robusta poplar, green ash, and hackberry.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 4

This group consists of well drained and moderately well drained, medium-textured and moderately fine textured, steep or very steep soils of the Gara, Lindley, Shelby, and Storden series. Slopes face north and northeast. Permeability is moderate to moderately slow. Available moisture capacity is high. The chief limitations to tree growth are plant competition and lack of sufficient moisture because of climate and runoff.

The suitability rating of these soils is good for hardwoods and good to very good for conifers and cottonwood trees. Production of timber from existing stands generally ranges from 150 to 200 board feet per acre per year, but it is less than 100 on the Storden soil. The average site index for upland hardwoods generally ranges from 56 to 65, but it is less than 45 on the Storden soil.

Seedling mortality is slight. Plant competition from grass or weeds or undesirable species is moderate. The equipment limitation is moderate. The hazard of erosion is severe.

Trees to favor in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Trees most suitable for openland, noncommercial plantings or plantings for wildlife habitat or for beautification are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, Douglas-fir, black walnut, green ash, and hackberry. In addition to these species, trees suitable for noncommercial interplanting in existing stands are red oak, white oak, and basswood.

Species most suitable for windbreaks are the conifers, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir, and the hardwoods, Norway poplar, Siouxland poplar, robusta poplar, green ash, and hackberry.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 5

This group consists of well drained to moderately well drained, medium-textured to moderately fine textured, steep or very steep soils of the Gara, Lindley, Shelby, and Storden series. These soils are on uplands. Slopes face south and southwest. Permeability is moderate to moderately slow. Available moisture capacity is high. The main limitations to tree growth are plant competition and lack of sufficient moisture because of climate and runoff.

The suitability rating of these soils is fair to good for hardwood, conifers, and cottonwood trees. Production of timber from existing stands generally ranges from 100 to 150 board feet per acre per year, but it is less than 100 on the Storden soil. The average site index for upland hardwoods generally ranges from 46 to 55, but it is less than 45 on the Storden soil.

Seedling mortality is slight. Plant competition from grass or weeds or undesirable species is moderate. The equipment limitation is moderate. The hazard of erosion is severe.

Trees to favor in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Trees most suitable for openland, noncommercial plantings or plantings for wildlife habitat or beautification are eastern white pine, red pine, Scotch pine, eastern red cedar, Norway spruce, European larch, Douglas-fir, black walnut, green ash, and hackberry. In addition to these species, trees suitable for noncommercial interplanting in existing stands are red oak, white oak, and basswood.

Species most suitable for windbreaks are the conifers, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir, and the hardwoods, Norway poplar, Siouxland poplar, robusta poplar, green ash, and hackberry. Honeysuckle, lilac, and ninebark are suitable shrubs.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 6

This group consists of somewhat poorly drained medium-textured and moderately fine textured, nearly level soils of the Cylinder, Ely, Macksburg, Nevin, and Nicollet series. These soils are on uplands. The Cylinder soil is underlain at a depth of about 24 to 40 inches by sand and gravel. Permeability is generally moderate to

moderately slow, but it is very rapid in the underlying sand and gravel of the Cylinder soil. Available moisture capacity is generally high, but it is moderate in the Cylinder soil. Runoff is slow. The chief limitation to tree growth is wetness.

The suitability rating of these soils is good for hardwoods and conifers and very good for cottonwood trees. Production of timber from existing stands ranges from 150 to 200 board feet per acre per year. The average site index for hardwoods ranges from 56 to 65.

Seedling mortality is slight. Plant competition from undesirable species is moderate. The equipment limitation is slight. The hazard of erosion is slight.

Trees to favor in existing stands are green ash, hackberry, white oak, red oak, and cottonwood.

Trees most suitable for openland, noncommercial plantings or plantings for wildlife habitat or for beautification are eastern white pine, Scotch pine, red pine, Norway spruce, eastern redcedar, European larch, green ash, walnut, and hackberry. In addition to these species, a tree suitable for noncommercial interplanting in existing stands is basswood.

Trees most suitable for windbreaks and wildlife plantings are the conifers, eastern white pine, Scotch pine, red pine, Norway spruce, and eastern redcedar, and the hardwoods, Norway poplar, Siouxland poplar, robusta poplar, green ash, and hackberry. Honeysuckle and red-osier dogwood are suitable shrubs.

WOODLAND SUITABILITY GROUP 7

This group consists of moderately well drained to poorly drained soils of the Adair, Clanton, Clarinda, Gosport, and Lamoni series. These soils are on uplands. Slopes are mainly 5 to 18 percent but some are as steep as 30 percent. Permeability is very slow or slow. Available moisture capacity is moderate to high. Runoff is rapid. The chief limitations to tree growth are wetness and permeability of the soils.

The suitability rating of these soils is fair to poor for hardwoods, poor for conifers, and fair for cottonwood trees. Production of timber from existing stands of upland hardwoods is less than 100 board feet per acre per year. The average site index for upland hardwoods is less than 45.

Seedling mortality is slight. Plant competition from undesirable species is slight. The equipment limitation is moderate. The hazard of erosion is slight to severe.

Trees to favor in existing hardwood stands are green ash, hackberry, and cottonwood.

Trees most suitable for openland, noncommercial plantings or plantings for wildlife habitat or for beautification are redcedar, Scotch pine, green ash, hackberry, and cottonwood.

Trees most suitable for windbreaks are the conifers, redcedar and Scotch pine, and the hardwoods, green ash, hackberry, and cottonwood. Windbreak site quality is good for green ash, hackberry, and cottonwood and poor for redcedar and Scotch pine.

WOODLAND SUITABILITY GROUP 8

This group consists of nearly level, moderately well drained or somewhat poorly drained, medium-textured soils of the Kennebec, Nodaway, and Spillville series. These soils are on bottom lands. Permeability is moderate. Available moisture capacity is high. Runoff is slow.

The suitability rating of these soils is fair for upland hardwoods, poor for conifers, and fair to good for bottom-land hardwoods (fig. 12). Production of timber from existing stands of bottom-land hardwoods ranges from 300 to 700 board feet per acre per year.

Seedling mortality is slight to moderate. Plant competition from undesirable species is moderate to severe, depending on weed population. Weeds, such as giant ragweed, sometimes grow on these rich, moist, bottom-land soils, making it difficult for new plantings to grow. The equipment limitation is slight. Erosion is not a hazard.

Trees to favor in existing stands are cottonwood, soft maple, and green ash.

Trees suitable for windbreaks are cottonwood, soft maple, and green ash, particularly cottonwood and soft maple.

WOODLAND SUITABILITY GROUP 9

This group consists mainly of poorly drained and very poorly drained soils of the Calco, Canisteo, Clearfield, Colo, Harps, Humeston, Okoboji, Vesser, Webster, and Zook series. Also included are Alluvial land and Marsh and Colo-Judson and Colo-Spillville complexes. These soils are on uplands and bottom lands. Most of these soils are nearly level, but some are in depressions and others have slopes of as much as 14 percent. The Clearfield, Judson, and Spillville soils are moderately well drained to somewhat poorly drained. Some of the soils are calcareous at or near the surface. They range from medium to fine in texture. Permeability generally ranges from moderate to slow, but it is very slow in the subsoil of the Humeston soil. The chief limitations to tree growth are wetness and poor drainage.

The suitability of these soils for commercial wood crop production is fair to poor.

Figure 12.—**Harvesting elm, soft maple, and cottonwood trees on the Middle Raccoon River bottoms. The soil is Nodaway silt loam, channeled.**

Trees suited to these soils are soft maple, cottonwood, sycamore, willow, green ash, and hackberry. Site suitability for the above kinds of trees is good. Some bottom-land areas are now in trees.

Also suited to these soils are redcedar, eastern white pine, Scotch pine, Norway spruce, and European larch. These conifers are suited mainly to the soils on uplands.

Use of the soils for wildlife

Guthrie County supports many kinds of wildlife that contribute to its income and recreational facilities. The kinds and numbers of wildlife that can be maintained are determined largely by the kinds and amounts of plants that the soils can produce and the distribution of these plants.

Topography affects wildlife mainly through its effect on soil use. For example, extremely rough, irregular areas are a hazard to livestock and unsuited to crops in places. If these areas are left undisturbed, the plants are commonly valuable as food or cover for wildlife. Suitable vegetation can be provided where it is lacking and the areas developed for desirable kinds of wildlife. Fertile soils are capable of producing more wildlife habitat than infertile soils. The wetness of the soils and their water-holding capacity are important in selecting sites for ponds and in maintaining aquatic or semiaquatic habitat for wildfowl and some kinds of furbearing animals.

Much of the natural wildlife habitat is along the major and minor streams and adjacent to strongly sloping to steep soils of the Lindley, Gara, Shelby, Gosport, Hesch, and Montieth series. More nearly level soils, such as those of the Nicollet and Webster series, provide limited shelter and nesting areas for birds and other wildlife. Corn and other grain are a source of food.

The wildlife of Guthrie County provides many opportunities for hunting and fishing. Many kinds of wildlife are beneficial because they eat harmful insects and rodents.

Pheasant, cottontail rabbit, squirrel, and deer are the game species that provide much of the hunting in the county. The distribution of pheasant and rabbit is fairly uniform over the county. However, the soils in associations 1 and 2, mainly Webster, Nicollet, and Clarion soils, are used intensively for row crops, and the cover needed for shelter and nesting is limited. Squirrel and deer are in the greatest number in stream bottom lands and the adjacent uplands of soil associations 4, 6, and 8, where the trees, food supply, and cover favor these animals. The main soils in the bottom lands are of the Colo, Zook, Kennebec, and Nodaway series, and soils on the adjacent uplands are of the Lindley, Gara, Ladoga, and Clinton series. Opossum, raccoon, weasel, woodchuck, badger, fox, and skunk are in variable numbers throughout the county. Muskrat and mink frequent streams throughout the county and use the marshes that are mainly in soil associations 1 and 2.

Fish, mainly channel catfish, bullheads, and carp, are fairly numerous in the major streams. There are many privately owned ponds in the county as well as some by the State. These provide fishing for bass, bluegill, crappie, and catfish.

Migrating wildfowl use areas of marsh and adjacent bodies of water for feeding and resting. Many areas that cannot be used for crops are well suited to the production of wildlife habitat. On most farms, areas can be developed for wildlife habitat. Gara, Shelby, Ladoga, Adair, Clarinda, Hesch, Montieth, Salida, and Storden soils are likely to have these kinds of areas. Also suitable are small, steep, eroded or gravelly areas of cropland, gravel pits, railroad rights-of-way, or tracts of land cut off from the rest of a field by a stream or drainage ditch. Even on soils that are suitable for crops, wildlife habitat can be produced as a primary or secondary crop for income or recreational purposes.

Use of the soils for recreation

The nature of occurrence and the properties of soils, abrupt changes in topography, and the vegetation in Guthrie County provide favorable conditions for recreational facilities. The fact that there are areas with rough topography in close proximity to fertile, intensively farmed soils adds to the scenic interest and potential value for recreation.

A number of recreational facilities have already been developed in the county. Among these is Springbrook State Park north of Guthrie Center. It has facilities for fishing, swimming, hiking, camping, and picnicking. Increased travel by the public and the short distance from the city of Des Moines provide the opportunity and need for more recreational facilities.

Soils and topography in all parts of the county provide good sites for ponding water. These soils include Shelby, Gara, Lindley, Gosport, and others. Publicly and privately owned stocked ponds and lakes, as well as the larger streams, provide sport fishing.

A guest ranch for children located near Guthrie Center, which features horseback riding and other activities, points up the opportunities for developing a number of types of facilities.

Good planning, development, and management are needed for any outdoor recreational facility. The soils of most capability units or woodland suitability groups provide wildlife habitat if properly used. The presence of wildlife makes outdoor recreation more enjoyable.

Engineering Uses of the Soils

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, facilities for storing water, erosion control structures, irrigation systems, drainage systems, building foundations, and sewage disposal systems. Among the properties most important to engineers are permeability, shear strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and reaction (pH). Depth to the water table, depth to bedrock, and topography are also important.

Information regarding the behavior and properties of the soil in Guthrie County can be obtained from the detailed soil map at the back of the survey and from tables 3, 4, and 5 in this section. The information in the tables was obtained and evaluated from field experience, field performance, and the result of tests such as those shown in table 5. The data contained in table 5, and other assistance as well, were furnished by the Iowa State Highway Commission.

The information in this survey can be used by engineers to—

1. Make soil and land use studies that will aid in the selection and development of industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils that will help in the planning of agricultural drainage systems, farm ponds, irrigation systems, terraces, waterways, and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel, sand, or other construction materials.
5. Correlate performance of engineering structures with mapping units to develop information for planning that will be useful in designing and maintaining specified engineering practices and structures.
6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs to make maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

The engineering interpretations can be useful for many purposes. It should be emphasized, however, that they do not eliminate the need for sampling and testing at the site of specific engineering works that involve heavy loads, or where the excavations are deeper than the depth of the layers reported. Even in these situations, however, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that can be expected.

Some terms used by the soil scientist have special meaning in soil science and are unfamiliar or have a different meaning to engineers. Many of these terms are defined in the Glossary at the back of this survey.

Engineering classification

Most highway engineers classify soil material according to the system approved by the American Association of State Highway Officials (AASHO) (*1*). In this system soil materials are placed in seven principal groups based on field performance. The groups range from A-1, consisting of gravelly and coarse, sandy soils of high bearing capacity, to A-7, consisting of clayey soils having low strength when wet.

Some engineers prefer to use the Unified Soil Classification System (*37*). This system is based on the texture and plasticity of soils and the performance of soils as material for engineering works. In this system, soil materials are classified as coarse-grained (eight classes), fine-grained (six classes), or highly organic (one class). An approximate classification can be made in the field. The soil series and land types in Guthrie County have been classified by the AASHO and Unified systems in table 3.

Engineering interpretations

Information of significance to engineers is given in tables 3, 4, and 5.

In table 3 the soil series in Guthrie County are listed, and estimates of the behavior of each soil are given. Some of the estimates were made on the basis of tests of samples from two soil series. The results of those tests are shown in table 5. For those soils not listed in table 5, properties were estimated by using data from those series, or similar series, in other counties in Iowa.

Depth to bedrock is not given in table 3, because bedrock is at a depth of more than 5 feet in most soils in the county. See the series descriptions for depth to bedrock of the Gosport, Clanton, Montieth, and Hesch soils.

Permeability is estimated for each soil as it occurs in place. The estimates were based on soil structure and porosity and were compared to undisturbed cores of similar soil material.

The available water capacity is expressed in this table in inches per inch of soil depth. Available water capacity is the capacity to hold the water for use by most plants. It is the difference between the amount of soil water at field capacity and the amount at wilting point.

Reaction, or pH, is the degree of acidity or alkalinity. The pH of a neutral soil is 7.0, of an acid soil is less than 7.0, and of an alkaline soil is more than 7.0. Many soils in Guthrie County are acid.

The shrink-swell potential indicates the change in volume that occurs with a change in moisture content. It is estimated primarily on the basis of the kind and amount of clay present.

In table 4 the soils in each series are rated for their suitability for use as topsoil, sand, gravel, and road fill. The suitability of soil material for road fill depends largely on the density that can be obtained by compacting the material. Density affects the rigidity, flexibility, and load-bearing properties of the soil as subgrade fill for paved roads and as surfacing material for unpaved roads. Shrink-swell potential is also a factor in evaluating material for road fill.

Soil features affecting the use of soils for highway location, farm ponds, agricultural drainage, irrigation, terraces and diversions, and waterways are given in table 4. Features that have an adverse effect on these practices generally are listed, but beneficial features are listed in some cases. Special features affecting highway construction are discussed elsewhere in this section.

Also rated in table 4 are the soil features affecting suitability of each soil series for foundations for low buildings and the degree of limitation if they are used for septic tank disposal fields. Soil features that affect foundations for low buildings are bearing capacity, compressibility, height of the water table, and other important features. These features vary widely. Engineers and others should not apply specific values to the estimates given for bearing capacity. For septic tank disposal fields, the soils are rated for their ability to absorb sewage effluent over a long period. Before a septic tank and field are installed, however, a percolation test should be made at the site. A sewage system close to a well or stream contaminates the water in places.

TABLE 3.—*Estimated soil*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. Because that appear in the first column. Symbol >

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification — USDA texture	Classification — Unified
	Feet	*Inches*		
Adair: 192D2, 192E2, 192E3	(1)	0–11	Clay loam	CL
		11–33	Medium clay loam to clay	CL or CH
		33–60	Clay loam	CL
Alluvial land: 315. Soil properties are too variable to be estimated.				
Armstrong. Mapped only in a complex with a Gara soil.	(1)	0–12	Loam	CL
		12–26	Clay and heavy clay loam	CH
		26–40	Clay loam	CL
		40–53	Sandy clay loam	CL or SC
Calco: [2] 733	1–3	0–34	Silty clay loam	OL or CH
		34–60	Silty clay loam or clay loam	CL or CH
Canisteo: 507	2–4	0–18	Silty clay loam	OH to CL
		18–28	Clay loam	CL
		28–60	Sandy clay loam to loam	CL or SC
Clanton: 318F	>5	0–11	Silty loam	ML-CL to CL
		11–60	Silty clay and clay	CH
Clarinda: 222C2, 222D2	(1)	0–16	Silty clay loam	CL or ML
		16–57	Clay	CH
Clarion: 138B, 138B2, 138C, 138C2, 138D2, 138E	>5	0–11	Loam	CL
		11–30	Loam and sandy clay loam	CL
		30–60	Loam	CL
Clearfield: 69D2	[1] 1–3	0–15	Silty clay loam	ML-CL
		15–35	Silty clay loam	CH
		35–48	Silty clay	CH
Clinton: 80B, 80C2, 80D2, 80D3	>5	0–9	Silt loam	ML or CL
		9–41	Silty clay loam	CL
		41–60	Silty clay loam	CL
*Colo: 133A, 133B, C133A, 133A+, 133B+, 11B, 585B, 615B. For properties of Judson soil in mapping unit 11B and Spillville soil in mapping units 585B and 615B refer to Judson and Spillville series.	1–3	0–39	Silty clay loam	OL or CH
		39–68	Silty clay loam	CH or CL
Cylinder: 203	2–4	0–16	Loam	CL or OL
		16–38	Loam and sandy loam	CL or SC
		38–66	Gravelly loamy sand	SM or SP
*Dickinson: 675C2, 675D2. For properties of Sharpsburg soil in mapping units 675C2 and 675D2, refer to Sharpsburg series.	>5	0–14	Fine sandy loam	SM or SC
		14–30	Fine sandy loam	SM or SC
		30–60	Loamy fine sand	SM
Ely: 428B	2–6	0–24	Silty clay loam	CL or OL
		24–60	Silty clay loam	CL
*Gara: 179D2, 179E2, 179F2, 179G2, 993E2. For properties of Armstrong soil in mapping unit 993E2, refer to Armstrong series.	>5	0–9	Loam	CL
		9–30	Clay loam	CL or CH
		30–60	Clay loam	CL
Gosport: 313E2, 313F2	>5	0–13	Silt loam	ML-CL to CL
		13–46	Silty clay loam and silty clay	CH
		46–60	Silty clay loam to silty clay shale.	CH

properties significant in engineering

these soils may have different properties and limitations, it is necessary to follow carefully the instructions for referring to other series means more than, < means less than]

Classification—Con. AASHO	Percentage passing sieve— No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction	Shrink-swell potential
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-6(8-12)	95-100	80-95	60-80	0. 2-0. 63	0. 17	6. 1-6. 5	Moderate.
A-7-6(15-20)	95-100	80-95	55-80	0. 06-0. 2	. 15	5. 6-6. 5	High.
A-6(8) to A-7-6(14)	95-100	80-95	55-80	0. 2-0. 63	. 15	6. 6-7. 8	Moderate.
A-6(8-12)	95-100	80-95	60-80	0. 2-0. 63	. 17	5. 6-6. 5	Moderate.
A-7-6(15-20)	95-100	80-95	55-80	0. 06-0. 20	. 15	5. 4-5. 0	High.
A-6(8) to A-7-6(14)	95-100	80-95	55-80	0. 2-0. 63	. 16	4. 5-5. 5	Moderate or high.
A-6(6-10)	95-100	80-95	40-55	0. 63-2. 0	. 14	5. 6-6. 0	Moderate.
A-7-5 to A-7-6(14-19)	100	100	85-100	0. 2-0. 63	. 21	7. 4-8. 4	High.
A-7-6(14-19)	100	100	80-100	0. 2-0. 63	. 18	7. 4-7. 8	High.
A-7-5 or A-7-6(10-14)	100	95-100	70-90	0. 63-2. 0	. 21	7. 4-8. 4	Moderate or high.
A-6(10) to A-7-6(14)	100	95-100	60-80	0. 63-2. 0	. 17	7. 4-8. 4	Moderate or high.
A-6(6-12)	100	95-100	40-75	0. 63-2. 0	. 15	7. 4-8. 4	Moderate.
A-6(8-12)	100	100	85-100	0. 63-2. 0	. 17	<4. 5-5. 5	Moderate.
A-7-6(18-20)	100	100	90-100	<0. 06	. 14	<4. 5	High.
A-6(6-10) to A-7-6(14)	100	95-100	85-100	0. 2-0. 63	. 18	5. 6-6. 5	High.
A-7-6(20)	100	95-100	85-100	<0. 06	. 15	6. 1-7. 3	High.
A-6(5-9)	95-100	96-100	55-75	0. 63-2. 0	. 19	6. 6-7. 3	Moderate.
A-4(4) to A-6(9)	90-100	85-100	50-75	0. 63-2. 0	. 17	6. 1-7. 3	Moderate or low.
A-4(4) to A-6(9)	90-100	85-95	50-70	0. 63-2. 0	. 16	7. 4-7. 8	Moderate or low.
A-7-6(13-18)	100	100	96-100	0. 2-0. 63	. 21	6. 1-7. 3	High.
A-7-6(15-20)	100	100	96-100	0. 2-0. 63	. 19	6. 1-7. 3	High.
A-7-6(20)	100	95-100	80-100	<0. 06	. 15	6. 6-7. 3	High.
A-6(10) to A-7-6(12)	------------	100	95-100	0. 63-2. 0	. 18	5. 1-6. 5	Moderate or high.
A-7-6(12-15)	------------	100	95-100	0. 2-0. 63	. 17	4. 5-5. 5	Moderate or high.
A-6(10) to A-7-6(13)	------------	100	95-100	0. 63-2. 0	. 15	5. 6-6. 0	Moderate or high.
A-7-5 or A-7-6(14-20)	100	100	85-100	0. 2-0. 63	. 21	6. 6-7. 3	High.
A-7-6(14-20)	100	100	80-100	0. 2-0. 63	. 19	6. 6-7. 3	High.
A-6(8-12) to A-7-5 (8-12)	100	90-100	50-75	0. 63-2. 0	. 18	6. 6-7. 3	Moderate.
A-4(1) to A-6(8)	95-100	80-100	30-60	0. 63-2. 0	. 15	6. 6-7. 8	Moderate.
A-1 or A-2-4(0)	75-95	50-90	10-30	>6. 3	. 02	7. 9-8. 4	Low.
A-4(0-3)	100	80-100	35-50	2. 0-6. 3	. 12	6. 1-7. 3	Low.
A-4(0-3)	100	80-100	35-50	2. 0-6. 3	. 10	6. 1-6. 5	Low.
A-2-4(0)	100	75-100	10-30	>6. 3	. 03	6. 6-7. 3	Very low.
A-7-6(12-17)	100	95-100	90-100	0. 63-2. 0	. 21	6. 1-6. 5	Moderate or high.
A-7-6(12-17)	100	95-100	90-100	0. 63-2. 0	. 19	6. 1-6. 5	Moderate or high.
A-4(3) to A-6(8)	90-100	80-100	55-70	0. 63-2. 0	. 18	5. 6-6. 5	Moderate.
A-6(9) to A-7-6(16)	90-100	80-100	55-80	0. 2-0. 63	. 17	5. 6-7. 3	Moderate or high.
A-6(9) to A-7-6(16)	90-100	80-100	50-80	0. 2-0. 63	. 16	7. 4-7. 8	Moderate.
A-6(8-12)	------------	100	85-100	0. 63-2. 0	. 18	5. 1-6. 0	Moderate.
A-7-6(14-20)	------------	100	98-100	<0. 06	. 15	5. 1-5. 5	High.
A-7-6(20)	------------	100	98-100	<0. 06	. 10	5. 6-6. 5	High.

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification	
			USDA texture	Unified
	Feet	*Inches*		
Harps: 95	1–3	0–16	Loam	OL to CL
		16–29	Loam	CL
		29–60	Loam	CL or ML
Hesch: 416E, 417D, 417E	>5	0–12	Sandy loam	SM
		12–24	Sandy loam	SM
		24–60	Loamy sand and sand	SM or SP–SM
Humeston: [2] 269	0–3	0–12	Silt loam	OL or CL
		12–18	Silt loam	ML or CL
		18–60	Silty clay loam	CH
Judson: 8B, 8C	3–6	0–27	Silty clay loam	CL or OL
		27–64	Silty clay loam and silt loam	CL
Kennebec: [2] 212	3–5	0–23	Silt loam	OL or CL
		23–60	Silty clay loam	CL
Ladoga: 76A, 76B, 76C, 76C2, 76D, 76D2, 76E2, T76B	>5	0–9	Silt loam	ML or CL
		9–32	Silty clay loam	CL
		32–60	Silty clay loam	CL
Lamoni: 822D2, 822E2	(1)	0–14	Silty clay loam and clay loam	CL
		14–37	Clay loam and clay	CH
		37–55	Clay loam	CL
Lester: 236B, 236C2, 236D2	>5	0–11	Loam	ML–CL or CL
		11–52	Clay loam	CL
Lindley: 65E2, 65F2, 65G2, 65F3	>5	0–9	Loam	CL
		9–52	Clay loam	CL
Macksburg: 368	2–4	0–18	Silty clay loam	ML–CL
		18–50	Silty clay loam	CH
		50–72	Silty clay loam	CH or CL
Marsh: 354	0		Variable	OH to ML
Marshall: 9B, 9C2, 9D2, T9B	>5	0–15	Silty clay loam	ML–CL or CL
		15–45	Silty clay loam	ML–CL or CL
		45–80	Silt loam	ML–CL or CL
Montieth: 415D, 415E, 415F	>5	0–12	Loamy sand and sand	SM or SP–SM
		12–34	Sand and sandy loam	SM or SP–SM
		34–50	Moderately cemented sandstone.	
Nevin: 88	2–4	0–16	Silty clay loam	CL or OL
		16–38	Silty clay loam	CL or CH
		38–45	Clay loam	CL
		45–54	Sandy loam	SM or SC
Nicollet: 55A	3–6	0–17	Loam	CL or ML–CL
		17–37	Clay loam	CL
		37–51	Loam	CL
Nodaway: [2] 220, C220	3–6	0–36	Silt loam	ML or CL
		36–60	Stratified sandy loam, loamy sand and loam.	CL to SM
Okoboji: 6	0–3	0–23	Silty clay loam	OH to CH
		23–60	Silty clay loam	CH to CL

significant in engineering—Continued

Classification—Con.	Percentage passing sieve—						
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction	Shrink-swell potential
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-6(8) to A-7-6(13)	100	95-100	65-80	0. 63-2. 0	0. 18	7. 9-8. 4	Moderate or high.
A-6(8) to A-7-6(13)	100	95-100	65-80	0. 63-2. 0	. 17	7. 9-8. 4	Moderate or high.
A-6(8-12)	95-100	90-100	60-75	0. 63-2. 0	. 16	7. 9-8. 4	Moderate.
A-2-4(0) to A-4(4)	100	90-100	25-40	2. 0-6. 3	. 13	5. 1-5. 5	Low.
A-2-4(0) to A-4(4)	100	90-100	25-40	2. 0-6. 3	. 10	5. 6-6. 0	Low.
A-2-4 or A-3(0)	100	90-100	8-25	>6. 3	. 03	5. 6-6. 0	Very low.
A-6(8-10)	------------	100	95-100	0. 63-2. 0	. 20	6. 1-6. 5	Moderate.
A-6(10) to A-7-6(14)	------------	100	95-100	0. 63-2. 0	. 18	6. 1-6. 5	Moderate.
A-7-6(17-20)	------------	100	95-100	<0. 06	. 16	6. 1-7. 3	High.
A-6(9) to A-7-6(13)	------------	100	90-100	0. 63-2. 0	. 22	6. 1-7. 3	Moderate.
A-6(6) to A-7-6(12)	------------	100	90-100	0. 63-2. 0	. 19	6. 1-7. 3	Moderate.
A-6(8-12) to A-7-6(10-14)	------------	100	90-100	0. 63-2. 0	. 21	6. 1-7. 3	Moderate.
A-6(8-12) to A-7-6(10-14)	------------	100	90-100	0. 63-2. 0	. 19	6. 1-6. 5	Moderate.
A-6(10) to A-7-6(14)	------------	100	95-100	0. 63-2. 0	. 18	6. 1-6. 5	Moderate.
A-7-6(14-16)	------------	100	95-100	0. 2-0. 63	. 17	5. 1-6. 0	Moderate or high.
A-7-6(10-14)	------------	100	95-100	0. 2-0. 63	. 17	5. 1-6. 0	Moderate or high.
A-6(10) to A-7-6(12)	95-100	95-100	70-95	0. 2-0. 63	. 19	6. 1-6. 5	Moderate or high.
A-7-6(16-20)	95-100	95-100	85-100	0. 06-0. 20	. 15	6. 1-7. 3	High.
A-6(10) to A-7-6(15)	85-100	85-100	55-85	0. 2-0. 63	. 16	7. 4-7. 8	Moderate.
A-4(6) to A-6(8)	95-100	95-100	60-80	0. 63-2. 0	. 21	6. 1-6. 5	Moderate.
A-4(4) to A-6(12)	95-100	90-100	60-80	0. 63-2. 0	. 17	5. 6-7. 3	Moderate.
A-4(3) to A-6(8)	85-95	80-90	55-65	0. 63-2. 0	. 17	5. 1-6. 5	Moderate.
A-6(9) to A-7-6(14)	85-95	80-90	50-65	0. 2-0. 63	. 16	5. 6-7. 8	Moderate.
A-7-5 to A-7-6(11-14)	------------	------------	95-100	0. 63-2. 0	. 21	5. 6-6. 0	High.
A-7-6(15-19)	------------	------------	95-100	0. 2-0. 63	. 19	5. 6-7. 3	High.
A-7-6(13-17)	------------	------------	95-100	0. 2-0. 63	. 19	6. 6-7. 3	High or moderate.
A-7-5 or A-7-6	[3]	[3]	[3]	[4]	[4]	[4]	Moderate or high.
A-7-6(10-14)	------------	100	95-100	0. 63-2. 0	. 21	5. 6-6. 5	Moderate.
A-7-6(12-16)	------------	100	95-100	0. 63-2. 0	. 19	5. 6-6. 5	Moderate.
A-7-6(10-14)	------------	100	95-100	0. 63-2. 0	. 20	6. 1-6. 5	Moderate.
A-2-4 or A-3	100	90-100	8-25	>6. 3	. 04	5. 6-6. 5	Low.
A-3 or A-2-4	100	90-100	5-25	>6. 3	. 04	4. 5-5. 5	Very low.
A-6(9) to A-7-6(14)	100	95-100	80-100	0. 63-2. 0	. 23	5. 6-6. 5	Moderate or high.
A-7-6(14-18)	100	95-100	80-100	0. 2-0. 63	. 20	6. 1-7. 3	High.
A-6(10) to A-7-6(14)	100	95-100	75-95	0. 2-0. 63	. 18	6. 6-7. 3	Moderate or high.
A-2-4 to A-4(6)	100	95-100	30-50	0. 63-2. 0	. 14	6. 6-7. 3	Moderate or low.
A-6(8) to A-7-6(14)	100	96-100	60-80	0. 63-2. 0	. 19	6. 1-6. 5	Moderate.
A-6(8) to A-7-6(14)	100	88-98	60-80	0. 63-2. 0	. 17	6. 1-7. 3	Moderate.
A-4(4) to A-6(12)	95-100	85-95	60-80	0. 63-2. 0	. 16	7. 4-8. 4	Moderate.
A-4(6) to A-6(10)	100	95-100	90-100	0. 63-2. 0	. 19	6. 6-7. 8	Moderate.
A-2-4(0) to A-6(10)	100	95-100	30-75	0. 63-6. 3+	0. 04-0. 14	7. 4-7. 8	Low.
A-7-6(14-18) or A-7-5(14-18)	100	100	80-95	0. 2-0. 63	. 21	6. 1-7. 3	High.
A-7-6(14-18) or A-7-5(14-18)	100	100	80-95	0. 06-0. 63	. 19	6. 6-7. 3	High.

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification: USDA texture	Classification: Unified
	Feet	*Inches*		
*Olmitz: 273B, 273C, 201B. For properties of Colo soils in mapping unit 201B, refer to Colo series.	>5	0–32	Loam or clay loam	OL or CL
		32–51	Clay loam	CL
		51–60	Clay loam or loam	CL
Salida: 73D2	>5	0–11	Sandy loam with some gravel	SM–SC or SM
		11–36	Gravelly loamy sand	SM or SP–SM
		36–60	Loamy sand and gravel	SP–SM or SM
Sharpsburg: 370A, 370B, 370C, 370C2, 370D, 370D2, 370E2, T370B	>5	0–13	Silty clay loam	ML–CL
		13–41	Silty clay loam	CH or CL
		41–53	Silty clay loam	ML–CL or CL
*Shelby: 24B, 24C2, 24D2, 24E2, 24F2, 24E3, 24F3, 93D2, 93D3, 93E2, 93E3. For properties of Adair soil in mapping units 93D2, 93D3, 93E2, and 93E3, refer to Adair series.	>5	0–14	Loam and clay loan	CL
		14–30	Clay loam	CL
		30–60	Clay loam	CL
Spillville:[2] 485A	3–5	0–40	Loam	OL or CL or MH
		40–60	Loam and fine sandy loam	SM to CL
Storden: 62C2, 62D2, 62E2, 62F2	>5	0–60	Loam	CL
Vesser:[2] 51A, 51A+	1–3	0–19	Silt loam	OL or CL
		19–34	Silt loam	ML or CL
		34–68	Silty clay loam	CL or CH
		68–72	Silt loam	ML or CL
Wadena:				
308A, 308B, 308C	>5	0–14	Loam	ML–CL or CL
		14–40	Loam	CL or SC
		40–60	Sand or loamy sand and gravel.	SP–SM, SM or SP
108A, 108B, 108C2	>5	0–16	Loam	ML–CL or CL
		16–27	Gravelly loam	SC to CL
		27–72	Gravelly loamy sand and loamy sand.	SP–SM, SM or SP
Webster: 107	2–4	0–21	Silty clay loam	OH to CL
		21–40	Gritty silty clay loam and clay loam.	CL
		40–60	Loam	CL
Zook:[2] 54+, 54	1–3	0–26	Silty clay loam	MH or CH
		26–60	Silty clay loam	CH

[1] Seasonally wet because of seepage from more permeable soils upslope.
[2] Soils subject to major flooding.

significant in engineering—Continued

Classification—Con.	Percentage passing sieve—						
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction	Shrink-swell potential
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-6(8) to A-7-6(14)	100	90-100	60-85	0. 63-2. 0	0. 18	5. 6-6. 5	Moderate.
A-6(8) to A-7-6(14)	100	90-100	60-85	0. 63-2. 0	. 17	6. 1-7. 3	Moderate.
A-6(8) to A-7-6(14)	95-100	90-100	60-85	0. 63-2. 0	. 17	6. 6-7. 3	Moderate.
A-2-4(0)	80-90	70-80	20-30	2. 0-6. 3	. 10	7. 4-7. 8	Low.
A-1-b or A-2-4(0)	80-90	70-80	10-25	>6. 3	. 04	7. 4-7. 8	Low.
A-1-b or A-2-4(0)	75-90	60-75	5-20	>20. 0	. 03	7. 4-7. 8	Very low.
A-6(8-12) to A-7-6 (10-14)	------------	100	95-100	0. 63-2. 0	. 21	6. 1-6. 5	High or moderate.
A-7-6(15-20)	------------	100	95-100	0. 2-0. 63	. 18	5. 6-6. 5	High.
A-7-6(12-15)	------------	100	95-100	0. 63-2. 0	. 19	6. 1-7. 3	High or moderate.
A-4(8) to A-6(12)	90-95	80-90	55-65	0. 63-2. 0	. 19	6. 1-6. 5	Moderate.
A-6(10) to A-7-6(14)	85-95	80-90	50-65	0. 2-0. 63	. 16	6. 1-6. 5	Moderate.
A-6(8) to A-7-6(14)	85-95	80-90	50-65	0. 2-0. 63	. 15	7. 4-7. 8	Moderate.
A-6(8) to A-7-5(14)	100	95-100	65-80	0. 63-2. 0	. 20	6. 6-7. 3	Moderate.
A-4(3) to A-6(10)	100	95-100	40-75	0. 63-6. 3	. 14	6. 6-7. 8	Moderate.
A-4(4) to A-6(12)	90-100	85-100	50-75	0. 63-2. 0	. 17	7. 4-8. 4	Moderate.
A-6(8-12)	100	100	90-100	0. 63-2. 0	. 20	6. 1-6. 5	Moderate.
A-6(8-10)	100	100	90-100	0. 63-2. 0	. 18	6. 1-6. 5	Moderate.
A-7-6(14-18)	100	100	90-100	0. 63-2. 0	. 19	6. 1-6. 5	Moderate or high.
A-6(8-12)	100	100	90-100	0. 63-2. 0	. 17	6. 1-6. 5	Moderate.
A-4 to A-6 (4-8)	100	95-100	55-70	0. 63-2. 0	. 17	6. 1-7. 3	Moderate.
A-4 to A-6 (4-8)	95-100	90-100	45-60	0. 63-2. 0	. 15	6. 6-7. 3	Moderate.
A-1-b(0)	70-95	60-80	3-15	>20. 0	. 05	7. 4-7. 8	Low.
A-4 or A-6 (4-8)	100	95-100	55-70	0. 63-2. 0	. 17	6. 1-7. 3	Moderate.
A-4 or A-6 (4-8)	95-100	90-100	45-60	0. 63-2. 0	. 15	6. 6-7. 3	Moderate.
A-1-b(0)	70-90	60-80	3-15	>20. 0	. 05	7. 4-7. 8	Low.
A-7-5 or A-7-6(10-14)	100	95-100	70-90	0. 63-2. 0	. 21	6. 6-7. 3	Moderate or high.
A-6(10) to A-7-6(17)	100	95-100	60-80	0. 2-2. 0	. 17	6. 6-7. 8	Moderate or high.
A-6(6) to A-7-6(14)	100	95-100	60-80	0. 63-2. 0	. 17	7. 8-8. 4	Moderate.
A-7-6(15) to A-7-5(20)	------------	100	90-100	0. 06-0. 20	. 19	6. 1-6. 5	High.
A-7-6(17-20)	------------	100	90-100	0. 06-0. 20	. 18	6. 1-7. 3	High.

[3] Not known.
[4] Variable.

TABLE 4.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. Because that appear in

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Adair: 192D2, 192E2 192E3.	Poor: thin layer of suitable material.	Unsuitable	Unsuitable	Very poor in subsoil: highly elastic and has high shrink-swell potential; fair or good in substratum.	Rolling topography; seasonal seepage in cuts; difficult to vegetate.	Slight compressibility; high shrink-swell potential; commonly seepy and wet.
Alluvial land: 315. Soil properties are too variable to be rated.						
Armstrong. Mapped only with Gara soils.	Very poor: low organic-matter content; thin layer of suitable material.	Unsuitable	Unsuitable	Fair to good in substratum, very poor in subsoil: highly elastic and has high shrink-swell potential.	Moderately steep; seasonally seepy and wet; good borrow potential in substratum; difficult to vegetate.	Commonly seepy and wet; high shrink-swell potential; slight compressibility.
Calco: 733	Fair: thick layer high in organic-matter content; calcareous.	Unsuitable	Unsuitable	Unsuitable: poor bearing capacity and shear strength; seasonal high water table; highly compressible; high in organic-matter content to a depth of about 3 feet.	Seasonal high water table; subject to flooding; poor foundation for high fills; stability and settlement should be analyzed.	Seasonal high water table; subject to flooding; high compressibility with uneven consolidation.
Canisteo: 507	Fair: moderately fine textured; calcareous.	Unsuitable	Unsuitable	Unsuitable: the upper 1½ to 2 feet is high in organic-matter content; often wet; seasonal high water table; fair bearing capacity.	Seasonal high water table; high in organic-matter content in the upper 1½ to 2 feet; settlement is a problem.	Fair bearing capacity; seasonal high water table; medium to high compressibility.
Clanton: 318F	Very poor: thin layer of suitable material; low fertility.	Unsuitable	Unsuitable	Unsuitable: highly elastic; poor stability; high shrink-swell potential; difficult to compact.	Steep slopes; unsuitable for borrow; very unstable; sloping shale.	High compressibility; poor bearing capacity and shear strength; high shrink-swell potential; very unstable.

interpretations of the soils

these soils may have different properties and limitations, it is necessary to follow carefully the instructions for referring to other series the first column]

Soil features affecting—Continued						Limitations of soil for septic tank disposal field
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir area	Embankment					
Suitable sites are common; very slow permeability if compacted; easily compacted at optimum moisture content.	Fair to good stability; high shrink-swell potential in subsoil, moderate below; good for impervious cores.	Seasonally wet and seepy; interceptor tile placed above seepage areas are helpful.	High available water capacity; slow intake rate; subject to erosion and runoff.	Subsoil unfavorable for root growth; difficult to vegetate; terrace channels likely to be seepy and wet.	Low fertility; wet and seepy in many places.	Severe: slow permeability.
Suitable sites are common; very slow permeability if compacted.	Fair to good stability; high shrink-swell potential in subsoil, moderate below; good for impervious cores.	Seasonally wet and seepy; interceptor tile placed above seepage areas are helpful.	High available water capacity; subject to runoff and erosion.	Subsoil unfavorable for root growth; difficult to vegetate; terrace channels likely to be seepy and wet.	Low fertility; wet and seepy in many places.	Severe: slow permeability.
Nearly level; high in organic-matter content to a depth of about 3 feet; slow permeability if compacted.	High organic-matter content to a depth of about 3 feet; fair to poor stability; generally poor compaction characteristics.	Poorly drained; moderately slow permeability; tile drains function satisfactorily, but good outlets are difficult to locate; surface drainage is beneficial in places.	Medium intake rate; high available water capacity; seasonal high water table; subject to flooding.	Not needed, because of topography.	Seasonal high water table and wetness; features affecting construction and vegetation favorable; waterways not needed in most areas.	Severe: seasonal high water table; subject to flooding; moderately slow permeability.
Nearly level; not suitable for conventional ponds; material below surface layer has slow permeability if compacted.	Not ordinarily used, because of position; fair stability and compaction characteristics below the surface layer; slow permeability if compacted.	Poorly drained; moderate permeability; tile drains function well.	High available water capacity; medium intake rate; artificial drainage is needed.	Not needed, because of topography.	Wetness may hinder construction at times; soil features are favorable.	Severe: seasonal high water table; moderately slow to moderate permeability.
Low seepage rate except in places where sandstone strata occur; these require a seal blanket at times.	Very unstable; high shrink-swell potential.	Steep slopes; drainage not needed.	Steep slopes; slow intake rate; moderate available water capacity.	Steep slopes; very difficult to vegetate clayey subsoil.	Steep slopes; very difficult to vegetate clayey subsoil.	Severe: very slow permeability; steep slopes.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Clarinda: 222C2, 222D2.	Very poor: thin layer of suitable material; low fertility.	Unsuitable	Unsuitable	Very poor: highly elastic; high shrink-swell potential; poor stability; difficult to compact; poor bearing capacity when wet.	Low borrow potential; seepage commonly occurs in cuts.	Poor shear strength; fair or poor bearing capacity; high shrink-swell potential; seasonally wet and seepy.
Clarion: 138B, 138B2, 138C, 138C2, 138D2, 138E.	Good: rather thin layer of material high in organic-matter content.	Unsuitable	Unsuitable	Good: good shear strength and bearing capacity; good workability characteristics; compacts readily to high densities.	Undulating topography; good source of borrow.	Good bearing capacity and shear strength; moderate or low shrink-swell potential; deep to the seasonal high water table.
Clearfield: 69D2	Fair: moderately fine textured.	Unsuitable	Unsuitable	Very poor: high compressibility; fair or poor compaction characteristics; high shrink-swell potential; seasonal high water table; very clayey substratum.	Wet and seepy; seasonal high water table; very poor source of borrow.	Poor bearing capacity; poor shear strength; high compressibility; high water table; seasonally seepy and wet.
Clinton: 80B, 80C2, 80D2, 80D3.	Poor: low organic-matter content.	Unsuitable	Unsuitable	Fair to poor: poor shear strength; fair or poor bearing capacity; moderate or high shrink-swell potential.	Gently to strongly sloping; high moisture content likely in deep cuts.	Poor shear strength; fair or poor bearing capacity; medium compressibility but uniform consolidation.

of the soils—Continued

Soil features affecting—Continued							Limitations of soil for septic tank disposal field
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways		
Reservoir area	Embankment						
Very slow permeability.	High shrink-swell potential; moderate compressibility.	Poorly drained; seepy and wet; very slow permeability; interceptor tile placed upslope reduces wetness in places.	Moderately sloping to strongly sloping; slow intake rate and very slow permeability; subject to runoff and erosion.	Subsoil very low in fertility; plastic; difficult to vegetate.	Difficult to vegetate where subsoil is exposed; seasonally wet and seepy.		Severe: very slow permeability; seasonal high water table.
Moderate permeability if not compacted, but slow when compacted; pockets of sand or gravel in places.	Good stability; can be used for impervious cores when compacted; stones and boulders in places; moderate or low shrink-swell potential.	Not needed	Gently sloping to moderately steep; undulating topography; high available water capacity; medium intake rate.	Complex topography hinders layout in places; soil features favorable except for stones and boulders in places.	Soil features favorable for construction and vegetation; stones and boulders in places.		Slight on slopes of less than 5 percent; moderate on slopes of 5 to 9 percent; severe on slopes of more than 9 percent; moderate permeability; deep to seasonal high water table.
Suitable sites not ordinarily available; very slow permeability in substratum.	Poor compaction and workability characteristics; high shrink-swell potential; commonly wet and seepy with a high water table.	Somewhat poorly drained to poorly drained; wetness due to seepage; interceptor tile placed on or above the silty clay substratum reduces wetness.	Slow intake rate; high available water capacity; wetness is generally a hazard.	Wetness and high water table commonly hinder construction; artificial drainage needed.	Seepage and high water table commonly hinder construction; artificial drainage needed.		Severe: very slow permeability; seepy with a seasonal high water table.
Slow permeability when compacted; low seepage rates.	Fair stability; poor compaction characteristics above optimum moisture content; fair at or below; moderate or high shrink-swell potential.	Not needed	Medium intake rate; high available water capacity; sloping soils subject to runoff and erosion.	Subsoil somewhat difficult to vegetate and till; other characteristics are favorable.	Subsoil somewhat difficult to vegetate and till; seepage causes wetness in places.		Slight on slopes of less than 5 percent; moderate on slopes of 5 to 9 percent; severe on slopes of more than 9 percent; moderately slow permeability at a depth above 4 feet, moderate below.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
*Colo: 133A, 133B, C133A, 133A+, 133B+, 11B, 585B, 615B. For properties of Judson soil in mapping unit 11B and Spillville soil in mapping units 585B and 615B, refer to Judson and Spillville series.	Fair or good: moderately fine textured; high organic-matter content.	Unsuitable	Unsuitable	Unsuitable: poor bearing capacity and shear strength; seasonal high water table; highly compressible; high in organic-matter content to a depth of about 3 feet or more.	Seasonal high water table; subject to flooding; poor foundation for high fills; should be analyzed for settlement and stability.	Seasonal high water table; subject to flooding; high compressibility and uneven consolidation.
Cylinder: 203	Good in upper 2 to 3 feet; medium textured; moderate organic-matter content; gravelly loamy sand below.	Fair below a depth of about 2 feet; variable amounts of fines and gravel; seasonal high water table.	Fair to poor: variable amounts of gravel; seasonal high water table.	Good: fair or good bearing capacity in upper part; good in substratum; sand and gravel has low shrink-swell potential and is suitable for subbase.	Nearly level; good source of borrow; seasonal high water table.	Good bearing capacity and shear strength in the substratum; low shrink-swell potential and compressibility; seasonal high water table.
*Dickinson: 675C2, 675D2. For properties of Sharpsburg soil in mapping units 675C2 and 675D2, refer to Sharpsburg series.	Fair or good: moderately coarse textured.	Fair or good: poorly graded; considerable fines.	Unsuitable	Good: good bearing capacity; very low compressibility; low shrink-swell potential.	Good workability characteristics except when fines are less than 15 percent; seepage and wetness likely in some deep cuts; very erodible.	Low compressibility; fair shear strength; good bearing capacity; subject to liquefaction and flow if saturated.
Ely: 428B	Good: thick surface layer high in organic-matter content.	Unsuitable	Unsuitable	Poor: fair or poor bearing capacity; high organic-matter content; moderate or high shrink-swell potential.	High organic-matter content; seasonal high water table; some areas subject to local flooding of short duration.	Fair or poor bearing capacity; high compressibility; some areas subject to local flooding of short duration.
*Gara: 179D2, 179E2, 179F2, 179G2, 993E2. For properties of Armstrong soil in mapping unit 993E2, refer to Armstrong series.	Fair: only thin layer with organic-matter content.	Unsuitable	Unsuitable	Good: good bearing capacity; good workability and compaction characteristics; easily compacted.	Strongly sloping to steep; seepage in some cuts; good borrow potential.	Good bearing capacity and shear strength; slight compressibility.

of the soils—Continued

Soil features affecting—Continued							Limitations of soil for septic tank disposal field
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways		
Reservoir area	Embankment						
Nearly level; high in organic-matter content; slow permeability if compacted.	High in organic-matter content in upper 3 feet or more; high shrink-swell potential; difficult to compact.	Poorly drained; moderately slow permeability; subject to flooding.	Medium intake rate; high available water capacity; seasonal high water table; subject to flooding.	Not needed because of topography.	Generally not needed; soil features favorable for construction and vegetation.		Severe: seasonal high water table; subject to flooding; moderately slow permeability.
Substratum too porous to hold water; suitable sites are uncommon.	Good stability; low shrink-swell potential; pervious and poor resistance to piping; seldom used, because of position.	Somewhat poorly drained; drainage not generally needed; underlain by sand and gravel.	Moderate available water capacity; medium intake rate.	Not needed because of topography.	Generally not needed; deep cuts lower the available water capacity and productivity.		Moderate: seasonal high water table; in places sand and gravel allow unfiltered sewage to travel long distances.
Material too porous to hold water.	Adequate strength and stability; low shrink-swell potential; pervious when compacted; susceptible to liquefaction and piping.	Not needed	Rapid intake rate; low available water capacity; sloping and subject to runoff and erosion.	Maintenance of terraces difficult; difficult to vegetate.	Highly erodible; difficult to vegetate.		Moderate on slopes of less than 5 to 9 percent, severe on slopes of more than 9 percent: poor filtering material; permits unfiltered sewage to travel some distance.
Gently sloping foot slopes and alluvial fans; generally slow permeability if compacted; high organic-matter content.	Adequate strength and stability below high organic-matter content surface layer; moderate to high shrink-swell potential.	Somewhat poorly drained; wetness generally due to seepage or local runoff; moderate permeability.	Medium intake rate; high available water capacity; gently sloping.	Soil features favorable for construction and vegetation; diversions properly placed help protect from local flooding by runoff.	Soil features favorable for construction and vegetation; seepage causes wetness in places.		Moderate: seasonal high water table in places.
Slow permeability when compacted; suitable sites are common.	Good stability; impervious when compacted; easily compacted; good for cores.	Moderately well drained; interceptor tile is useful in some places to control seepage at loess-till contact.	Sloping to steep soils subject to runoff and erosion; high available water capacity.	Soil features favorable; high density, low fertility subsoil; difficult to vegetate where exposed.	Soil features favorable; seasonal wetness due to seepage in places.		Severe: moderately slow permeability; slopes of more than 9 percent.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Gosport: 313E2, 313F2.	Poor: very thin layer of suitable material.	Unsuitable	Unsuitable	Unsuitable: very poor bearing capacity and shear strength; high shrink-swell potential.	Unsuitable for borrow; seasonally wet and seepy; soil above shale subject to sliding on the sloping shale surface.	Very poor shear strength and bearing capacity; high compressibility and shrink-swell potential; seasonal wetness and seepiness.
Harps: 95	Fair: high in calcium carbonates.	Unsuitable	Unsuitable	Very poor: seasonal high water table; high in organic-matter content to a depth of of 1½ feet; fair bearing capacity and shear strength.	Seasonal high water table; commonly wet.	Fair shear strength and bearing capacity; seasonal high water table; moderate or high shrink-swell potential.
Hesch: 416E, 417D, 417E.	Poor: moderately coarse textured; low fertility.	Fair: considerable fines.	Unsuitable	Good: good bearing capacity and shear strength; low shrink-swell potential; can liquefy and flow when wet.	Strongly sloping or moderately steep; sandstone substratum erodible when exposed.	Good bearing capacity and shear strength; subject to liquefaction and piping.
Humeston: 269	Fair in upper 18 inches: commonly wet; poor in clayey subsoil.	Unsuitable	Unsuitable	Unsuitable: highly elastic; high shrink-swell potential; poor bearing capacity and shear strength; seasonal high water table; moderately high in organic-matter content to a depth of of about 40 inches.	Depressed to nearly level topography; subject to ponding, flooding, and seasonal high water table; high embankments should be analyzed for settlement and stability.	Subject to flooding and ponding; high shrink-swell potential; seasonal high water table.
Judson: 8B, 8C	Good: thick layer high in organic-matter content.	Unsuitable	Unsuitable	Poor: high in organic-matter content in the upper 2 or 3 feet; fair to poor bearing capacity; poor shear strength; difficult to compact.	Gently and moderately sloping foot slopes and alluvial fans subject to flooding by local runoff in places; low borrow potential; high in organic-matter content.	Fair to poor bearing capacity; high compressibility with uneven consolidation in places; some areas have concentration of local runoff.

of the soils—Continued

Soil features affecting—Continued							Limitations of soil for septic tank disposal field
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways		
Reservoir area	Embankment						
Very slow permeability in places; contains lenses of sandstone which need a seal blanket in places.	Clayey subsoil and shale substratum have high shrink-swell potential and tend to creep in embankment; very slow permeability.	Not needed	Not suitable because of steep slopes, low agricultural potential, and very slow permeability.	Unsuitable because of clayey, infertile subsoil.	Very difficult to vegetate; clayey subsoil is very low in fertility and strongly acid.		Very severe: very slow permeability in subsoil and substratum.
Level; seasonal high water table; not ordinarily suited for pond sites.	Not ordinarily used, because of position; fair workability characteristics; seasonal high water table.	Poorly drained; moderate permeability.	High available water capacity; medium water intake rate; seasonal high water table.	Not needed because of topography.	Not ordinarily needed; seasonal high water table; too wet for earth moving at times.		Severe: moderate permeability; seasonal high water table; generally adjacent to very wet depressional soils.
Substratum too porous to hold water.	Fair stability; pervious; poor resistance to piping.	Well drained to somewhat excessively drained; drainage not needed.	Strongly sloping or moderately steep; low available water capacity.	Highly erodible; maintenance difficult.	Highly erodible; low available water capacity.		Slight: porous substratum allows unfiltered sewage to travel long distances.
Suitable sites are uncommon; very slow to slow permeability when compacted; subject to flooding.	Fair stability; high shrink-swell potential; not ordinarily used, because of position.	Poorly drained; very slow permeability; subject to ponding and flooding.	High available moisture capacity; subject to ponding and flooding; drainage needed.	Terraces not needed; in places properly placed diversions can reduce local ponding and wetness.	Not needed because of topography.		Severe: subject to ponding and flooding; seasonal high water table; very slow permeability.
High organic-matter content in the upper 2 to 3 feet; moderate permeability if not compacted.	Fair stability; high organic-matter content; high compressibility.	Moderately well drained; drainage not ordinarily needed.	High available water capacity; medium intake rate; gentle to moderate slopes.	Soil features are favorable for construction and vegetation; diversions properly placed help protect from local flooding by runoff from adjacent soils.	Soil features are favorable.		Slight on slopes of 2 to 5 percent; moderate on slopes of 5 to 9 percent; some areas subject to flooding of short duration by runoff from adjacent soils.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Kennebec: 212	Good: thick layer high in organic-matter content.	Unsuitable	Unsuitable	Poor: high in organic-matter content in the upper 2 to 3 feet; fair or poor bearing capacity; high compressibility.	Subject to flooding; high in organic-matter content in the upper 2 to 3 feet; poor foundation for high fills.	Fair or poor bearing capacity; high compressibility with uneven consolidation in places; subject to flooding.
Ladoga: 76A, 76B, 76C, 76C2, 76D, 76D2, 76E2, T76B.	Fair: thin layer high in organic-matter content.	Unsuitable	Unsuitable	Poor: fair or poor bearing capacity; poor shear strength; moderate or high shrink-swell potential; difficult to compact to high densities.	Nearly level to moderately steep; high moisture content in some deep cuts; low borrow potential.	Fair or poor bearing capacity; poor shear strength; medium compressibility; uniform consolidation.
Lamoni: 822D2, 822E2.	Very poor: moderately fine textured; thin layer of suitable material.	Unsuitable	Unsuitable	Very poor to a depth of about 3½ feet; elastic; high shrink-swell potential; fair to good below.	Strongly sloping to moderately steep; seasonally wet and seepy in cuts; low borrow potential.	High shrink-swell potential; fair bearing capacity.
Lester: 236B, 236C2, 236D2.	Good: only thin layer has organic-matter content.	Unsuitable	Unsuitable	Good: good bearing capacity and shear strength; good workability characteristics; easily compacted to high density; moderate shrink-swell potential.	Gently to strongly sloping; good source of borrow material.	Good bearing capacity and shear strength; low compressibility; moderate shrink-swell potential.
Lindley: 65E2, 65F2, 65G2, 65F3.	Poor: thin layer has low organic-matter content.	Unsuitable	Unsuitable	Good: good bearing capacity; slight compressibility; easily compacted to high density; moderate shrink-swell potential.	Moderately steep to very steep; good source of borrow; some cuts may be seepy.	Good bearing capacity and shear strength; slight compressibility.
Macksburg: 368	Fair: moderately fine textured.	Unsuitable	Unsuitable	Very poor: fair or poor bearing capacity; poor shear strength; high shrink-swell potential; high compressibility.	Very poor source of borrow; high in organic-matter content to a depth of about 1½ feet.	Fair or poor bearing capacity; high compressibility; high shrink-swell potential; seasonal high water table.

of the soils—Continued

Soil features affecting—Continued: Farm ponds: Reservoir area	Farm ponds: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Limitations of soil for septic tank disposal field
High organic-matter content; moderate permeability if not compacted.	High organic-matter content; high compressibility.	Subject to flooding; most areas do not need tile.	High available water capacity; medium intake rate; subject to flooding.	Not needed due to topography and position.	Generally not needed; no soil limitations.	Severe: subject to flooding; high water table in places.
Uniform material; slow permeability if compacted.	Fair stability; poor compaction characteristics at above optimum moisture; slow permeability when compacted; moderate or high shrink-swell potential.	Moderately well drained; drainage generally not needed.	Gently sloping to moderately steep; medium intake rate; high available water capacity; subject to runoff and erosion.	Soil features favorable.	Soil features are favorable.	Moderate on slopes of less than 9 percent, severe on slopes of more than 9 percent; moderately slow permeability in subsoil.
Very slow permeability if compacted.	Impervious when compacted; suitable for cores; high shrink-swell potential.	Interceptor tile helps control seepage in some areas.	Slow intake rate and permeability; strongly sloping to moderately steep slopes are subject to erosion and runoff.	Very low fertility in subsoil; clayey subsoils if exposed are difficult to vegetate; seasonally seepy and wet.	Difficult to vegetate where subsoils are exposed; seasonally seepy and wet.	Severe: slow permeability; seasonally seepy and wet.
Moderate permeability if not compacted, but generally low seepage rate if compacted; pockets of sand or gravel in places.	Good stability; can be used for impervious cores; stones or boulders in places; good resistance to piping.	Well drained; drainage not needed.	High available water capacity; medium intake rate; subject to runoff and erosion on gentle to strong slopes.	Soil properties are favorable except for stones or boulders in places.	Soil features are favorable except for stones or boulders in places.	Slight on slopes of less than 5 percent; moderate on slopes of 5 to 9 percent; and severe on slopes of more than 9 percent; moderate permeability; deep to seasonal high water table.
Good sites are common; slow permeability when bottom compacted.	Good stability; easily compacted to high density; usable for cores; slow permeability if compacted.	Moderately well drained.	Moderately steep to very steep slopes.	Moderately steep to very steep slopes; subsoil low in fertility.	Subsoil low in fertility.	Severe: slopes exceed 9 percent; moderately slow permeability in subsoil.
Suitable sites are uncommon because of topography and position.	Fair to poor stability; high compressibility; high shrink-swell potential; not ordinarily used, because of position.	Somewhat poorly drained; moderately slow permeability; most areas do not need drainage.	High available water capacity; medium intake rate; nearly level.	Not needed because of topography.	Soil properties favorable for construction and vegetation; some areas wet in waterways unless tiled.	Moderate: moderately slow permeability; in some areas water table is seasonally within 4 feet of surface.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Marsh: 354	Unsuitable: covered with water or very wet much of the time.	Unsuitable	Unsuitable	Unsuitable: very wet or under water much of the time.	Very poor location; under water or very wet much of the time.	Under water or very wet much of the time.
Marshall: 9B, 9C2, 9D2, T9B.	Good in surface layer; fair below: moderately fine textured.	Unsuitable	Unsuitable	Fair: fair or poor bearing capacity; fair shear strength; medium or high compressibility; fair workability and compaction characteristics.	Gently to strongly sloping; high moisture content in some deep cuts.	Fair or poor bearing capacity; fair shear strength; medium or high compressibility; fair resistance to piping.
Montieth: 415D, 415E, 415F.	Poor: coarse textured.	Fair: only thin over sandstone.	Unsuitable	Fair: good bearing capacity; underlain by moderately cemented sandstone at a depth of about 3 feet.	Strongly sloping to steep; moderately cemented sandstone at a depth of about 3 feet.	Underlain by moderately cemented sandstone at a depth of about 3 feet.
Nevin: 88	Good in surface layer; fair below; moderately fine textured; moderate organic-matter content to a depth of 1½ feet.	Unsuitable	Unsuitable	Poor: poor bearing capacity; fair shear strength; moderate or high shrink-swell potential; elastic; difficult to compact.	Nearly level; moderate in organic-matter content; seasonal high water table; low borrow potential.	Medium or high compressibility; poor bearing capacity; seasonal high water table.
Nicollet: 55A	Good: medium-textured surface layer; fairly thick layer of material moderate in organic-matter content.	Unsuitable	Unsuitable	Good: high or moderate organic-matter content to a depth of about 1½ feet; material below the surface has good bearing capacity and compacts easily.	Nearly level; high water table in places; moderate organic-matter content to a depth of about 1½ feet.	Good bearing capacity; fair shear strength; slight compressibility; in places a high water table occurs in wet seasons.
Nodaway: 220, C220.	Good: only low organic-matter content.	Unsuitable	Unsuitable	Poor to fair: poor to fair bearing capacity and shear strength; difficult to compact; low borrow potential because of position.	Nearly level; subject to frequent overflow; frequent changes in foundation support where old channels are present.	High compressibility; subject to frequent flooding; poor bearing capacity.

of the soils—Continued

Soil features affecting—Continued						Limitations of soil for septic tank disposal field
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir area	Embankment					
Not suited for conventional pond sites.	Unsuitable	Some potential for draining, but outlets are generally difficult to obtain.	Not applicable	Not applicable	Not applicable	Unsuitable: under water or very wet most of time.
Moderate permeability if not compacted; uniform material.	Fair stability; fair workability and compaction characteristics; moderate shrink-swell potential.	Well drained; drainage not needed.	High available water capacity; medium intake rate; gentle to strong slopes subject to runoff and erosion.	Soil features are favorable.	Soil features are favorable.	Slight on slopes of less than 5 percent; moderate on slopes of 5 to 9 percent; severe on slopes of more than 9 percent; moderate permeability.
Substratum too porous to hold water.	Moderately cemented sandstone at a depth of about 3 feet; material above is pervious and subject to liquefaction and piping.	Excessively drained; drainage not needed.	Strongly sloping to steep; very low potential for farming.	Moderately cemented sandstone at a depth of about 3 feet; very erodible.	Very erodible; moderately cemented sandstone at a depth of about 3 feet.	Moderately cemented sandstone at a depth of about 3 feet; unfiltered sewage travels long distances in places.
Suitable sites are uncommon; moderately slow permeability if not compacted.	Fair stability; difficult to compact; moderate or high shrink-swell potential.	Somewhat poorly drained; moderately slow permeability.	Medium intake rate; high available water capacity; nearly level.	Not needed because of topography.	Not generally needed because of topography; soil features are favorable.	Moderate: seasonal high water table in places; moderately slow permeability.
Suitable sites are uncommon; moderate permeability if not compacted.	Fair to good stability; medium in organic-matter content to a depth of about 1½ feet; material below compacts readily to high densities and can be used for cores.	Somewhat poorly drained; moderate permeability; drainage generally not needed.	High available water capacity; medium water intake rate; nearly level to gently sloping.	Generally not needed because of topography.	Soil features are favorable.	Moderate: high water table in places; moderate permeability.
Moderate permeability if not compacted.	Poor stability at high moisture content; difficult to compact to high density; poor resistance to piping.	Subject to flooding.	Medium intake rate; high available water capacity; subject to flooding.	Not needed because of topography.	Soil features are favorable.	Severe: subject to frequent flooding.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Okoboji: 6	Fair: thick layer high in organic-matter content; commonly wet.	Unsuitable	Unsuitable	Very poor: high organic-matter content in the upper 2 or 3 feet; poor bearing capacity; high compressibility with uneven consolidation.	Poor location; high water table in many places; subject to ponding; wet plastic soil materials; uneven consolidation likely; excavation of surface layer needed in places.	High water table in many places; high compressibility with uneven consolidation; poor bearing capacity; subject to ponding.
*Olmitz: 273B, 273C, 201B. For properties of Colo soils in mapping unit 201B, refer to Colo series.	Good: thick layer high in organic-matter content.	Unsuitable	Unsuitable	Poor: high in organic-matter content to a depth of 2 to 3 feet; fair or poor bearing capacity; moderate shrink-swell potential.	Gently to moderately sloping; high in organic-matter content to a depth of 2 to 3 feet; poor source of borrow.	Fair or poor bearing capacity; fair shear strength; medium compressibility; moderate shrink-swell potential.
Salida: 73D2	Very poor: low organic-matter content; gravelly.	Fair to poor: mixed sand and gravel; some areas contain considerable fines.	Fair to poor: mixed sand and gravel; some areas contain considerable fines.	Very good: good bearing capacity; low or very low shrink-swell potential; slight compressibility.	Undulating topography; good source of borrow material.	Good bearing capacity; good shear strength; low or very low shrink-swell potential.
Sharpsburg: 370A, 370B, 370C, 370C2, 370D, 370D2, 370E2, T370B.	Fair: moderately fine textured.	Unsuitable	Unsuitable	Poor: fair or poor bearing capacity; high shrink-swell potential; difficult to compact to high densities.	Nearly level to moderately steep; poor source of borrow.	Fair or poor bearing capacity and shear strength; high shrink-swell potential.
*Shelby: 24B, 24C2, 24D2, 24E2, 24F2, 24E3, 24F3, 93D2, 93D3, 93E2, 93E3. For properties of Adair soil in mapping units 93D2, 93D3, 93E2, and 93E3, refer to Adair series.	Fair: only thin layer of medium-textured material.	Unsuitable	Unsuitable	Good or fair: good bearing capacity; slight compressibility; good workability and compaction characteristics; easily compacted to high densities.	Gently sloping to steep; some cuts tend to be seepy; good borrow potential.	Good bearing capacity and shear strength; slight compressibility.

of the soils—Continued

Soil features affecting—Continued							Limitations of soil for septic tank disposal field
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways		
Reservoir area	Embankment						
Frequent high water table; not suited for conventional pond sites.	High organic-matter content in the upper 2 or 3 feet; not ordinarily used, because of position.	Very poorly drained; moderately slow to slow permeability; subject to ponding.	Very poorly drained; wetness and ponding are serious hazards.	Not needed because of topography.	Not needed because of topography.		Severe: frequent high water table; subject to ponding.
High in organic-matter content to a depth of 2 to 3 feet; moderate permeability if not compacted.	High in organic-matter content to a depth of 2 to 3 feet; fair stability; fair to poor workability and compaction characteristics; medium compressibility.	Moderately well drained; drainage not needed.	High available water capacity; medium intake rate; gently to moderately sloping; subject to erosion and gullying.	Soil features are favorable.	Soil features are favorable.		Slight on slopes of less than 5 percent, moderate on slopes of 5 to 9 percent: moderately permeable.
Substratum is too porous to prevent excessive seepage.	Fair stability; good compaction characteristics; slight compressibility; pervious and subject to piping; stones and boulders in places.	Excessively drained; drainage not needed.	Rapid water intake rate; very low available water capacity; undulating topography.	Shallow to sand and gravel; erodible and difficult to vegetate.	Shallow to sand and gravel; difficult to vegetate.		Slight to moderate: very rapid permeability allows unfiltered sewage to travel long distances in places.
Moderately slow permeability in subsoil and moderate permeability in substratum if not compacted; uniform material.	Fair stability; fair or poor compaction characteristics; high shrink-swell potential.	Moderately well drained; drainage not needed.	Gently sloping to moderately steep; high available water capacity; medium intake rate; subject to runoff and erosion.	Soil features are favorable.	Soil features are favorable.		Slight or moderate on slopes of less than 5 percent, moderate on slopes of 5 to 9 percent, severe on slopes of more than 9 percent: moderately slow permeability.
Moderately slow permeability if not compacted; suitable sites are common.	Good stability; easily compacted; good workability characteristics; suitable for cores.	Moderately well drained; in places seepy areas benefit from interceptor tile upslope.	Gently sloping to steep; high available water capacity; subject to runoff and erosion.	Soil features favorable for construction except for stones and boulders in places; subsoil is firm and low in fertility.	Soil features favorable for construction except for stones and boulders in places; subsoil is firm and low in fertility.		Moderate on slopes of 2 to 9 percent, severe on slopes of more than 9 percent: moderately slow permeability.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Spillville: 485A	Good: thick layer of medium-textured material high in organic-matter content.	Fair to unsuitable: in places poorly graded sand occurs below a depth of 4 to 5 feet; contains excess fines in places.	Unsuitable	Fair or poor: high or moderate organic-matter content to a depth of 3 feet or more; low density material.	Subject to flooding; moderate or high in organic-matter content in the upper 3 to 4 feet.	Subject to flooding; fair bearing capacity and shear strength; medium or high compressibility.
Storden: 62C2, 62D2, 62E2, 62F2.	Poor to fair: very low organic-matter content and fertility.	Unsuitable	Unsuitable	Good: good bearing capacity; easily compacted; slight compressibility.	Moderately sloping to steep, rolling topography; good source of borrow; silty pockets have frost-heaving potential in places.	Good bearing capacity and shear strength; slight compressibility; deep to seasonal high water table.
Vesser: 51A, 51A+	Good or fair: medium textured.	Unsuitable	Unsuitable	Fair or poor: fair or poor bearing capacity; moderate to high shrink-swell potential; difficult to compact.	Nearly level; seasonal high water table; poor foundation for high fills.	High compressibility; subject to flooding of short duration and high water table; uneven consolidation in places.
Wadena: 308A, 308B, 308C.	Good: medium textured.	Fair below a depth of about 3 to 3½ feet: mixed sand and gravel.	Good below a depth of 3 to 3½ feet: mixed sand and gravel.	Good: material below a depth of 3 to 3½ feet has good bearing capacity and shear strength; low shrink-swell potential; material above has fair or good bearing capacity and moderate shrink-swell potential.	Mostly nearly level; bench position; good source of borrow.	Good bearing capacity; slight compressibility; deep to water table.
108A, 108B, 108C2.	Good: medium textured.	Fair below a depth of 2 to 3 feet: mixed sand and gravel.	Good below a depth of 2 to 3 feet: mixed sand and gravel.	Good: material below a depth of 2 to 3 feet has good bearing capacity and shear strength; slight compressibility; low shrink-swell potential.	Mostly nearly level; bench position; good source of borrow.	Good bearing capacity; slight compressibility; deep to water table.

of the soils—Continued

Soil features affecting—Continued							Limitations of soil for septic tank disposal field
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways		
Reservoir area	Embankment						
Moderate or high in organic-matter content in the upper 3 feet or more; moderate permeability if not compacted.	Moderate or high in organic-matter content to a depth of 3 feet or more; fairly stable below.	Moderately well drained; drainage generally not needed; subject to flooding.	High available water capacity; subject to flooding.	Not needed because of topography; in places diversions placed upslope help reduce flooding and siltation.	Generally not needed because of position.		Moderate or severe: subject to flooding.
In places contains sand and gravel pockets that require a compacted seal blanket; low seepage rate if compacted.	Fair or good stability; slow permeability when compacted; stones or boulders in places; good for impervious cores and blankets.	Well drained; drainage not needed.	Slopes and low fertility limit use for irrigation.	Stones and boulders in places; low in fertility; irregular topography.	----------------		Moderate on slopes of less than 5 to 9 percent, severe on slopes of more than 9 percent: moderate permeability.
Suitable sites are uncommon; underlain by stratified materials at a depth of 5 feet or below in places.	Fair or poor stability; moderate or high shrink-swell potential; difficult to compact.	Poorly drained; moderate permeability.	High available water capacity; medium intake rate; poorly drained.	Not needed because of topography; diversions properly placed are beneficial in preventing local runoff and siltation.	Generally not needed; seasonal high water table and seepage cause wetness.		Severe: subject to flooding and seasonal high water table.
Substratum is too porous to hold water; not situated for reservoir areas.	Not ordinarily used because of position; good stability but pervious to water when compacted.	Well drained; drainage not needed.	Moderate available water capacity; medium intake rate.	Soil features favorable for construction; deep cuts lower the available water capacity.	Soil features are favorable for construction; deep cuts lower the available water capacity.		Slight on slopes of less than 5 percent, moderate on slopes of 5 to 9 percent: porous substratum allows unfiltered sewage to travel long distances.
Substratum is too porous to hold water; not situated for reservoir areas.	Not ordinarily used because of position; good stability but pervious to water when compacted.	Well drained; drainage not needed.	Low available water capacity; rapid permeability in substratum limits effective irrigation to a depth of 2 to 3 feet.	Sand and gravel at a depth of 2 to 3 feet; very low available water capacity in terrace channels.	Sand and gravel at a depth of 2 to 3 feet; very low available water capacity in waterway channels.		Slight on slopes of less than 5 percent, moderate on slopes of 5 to 9 percent: porous substratum allows unfiltered sewage to travel long distances.

TABLE 4.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Webster: 107	Fair: moderately fine textured; high in organic-matter content; seasonal high water table.	Unsuitable	Unsuitable	Unsuitable: the upper 1½ to 2 feet is high in organic-matter content; commonly wet; seasonal high water table.	Nearly level; seasonal high water table; high in organic-matter content in the upper 1½ to 2 feet.	Fair to poor bearing capacity; seasonal high water table; medium to high compressibility.
Zook: 54+, 54	Poor: moderately fine to fine textured; high in organic-matter content; seasonally wet.	Unsuitable	Unsuitable	Unsuitable: high shrink-swell potential; poor bearing capacity; seasonal high water table.	Nearly level; high organic-matter content; seasonal high water table; poor foundation for high fills.	Poor bearing capacity and shear strength; high shrink-swell potential; seasonal high water table.

[1] Engineers and others should not apply specific values to the estimates given for bearing capacity of soils.

TABLE 5.—*Engineering*

[Tests performed by Iowa State Highway

Soil name and location	Parent material	Report No.	Depth from surface	Moisture-density data [1]		Mechanical analysis [2]			
				Maximum dry density	Optimum moisture	Percentage passing sieve—			
						2 in.	1½ in.	1 in.	¾-in.
			Inches	*Lb. per cu. ft.*	*Percent*				
Storden loam: 650 feet south and 150 feet east of northwest corner of sec. 5, T. 81 N., R. 30 W.	Wisconsin till.	AAD7-2734	0-5	103	16	------	------	------	------
		AAD7-2735	9-19	112	12	100	99	98	97
		AAD7-2736	39-52	117	13	------	------	------	------
Olmitz loam: NE¼NE¼ sec. 3, T. 78 N., R. 32 W.	Local alluvium derived from till but including some loess.	AAD7-2737	7-14	98	19	------	------	------	------
		AAD7-2738	32-41	103	17	------	------	------	------
		AAD7-2739	51-61	105	18	------	------	------	100

[1] Based on AASHO Designation T 99-57, Method A(*1*).
[2] Mechanical analysis according to AASHO Designation T 88(*1*). Results by this procedure frequently differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, includ ing

of the soils—Continued

Soil features affecting—Continued							Limitations of soil for septic tank disposal field
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways		
Reservoir area	Embankment						
Level; suitable sites are not common.	Not ordinarily used because of position; fair stability and compaction characteristics below the surface layer; slow permeability when compacted.	Poorly drained; moderate or moderately slow permeability.	High available water capacity; medium intake rate; drainage is needed.	Not needed because of topography.	Wetness hinders construction at times; soil features are favorable.		Severe: seasonal high water table; moderately slow or moderate permeability.
Suitable sites are not common; level to depressed topography: subject to flooding.	Fair stability; impervious when compacted; high shrink-swell potential; high in organic-matter content.	Poorly drained; slowly permeable; tile is not effective in all places; some areas subject to flooding.	Intake rate varies with the amount of vertical cracking; high available water capacity; drainage needed.	Terraces not needed because of topography; diversions properly placed upslope help protect from runoff from adjacent uplands in places.	Generally not needed because of topography.		Very severe: slow permeability; seasonal high water table; some areas subject to flooding.

test data

Commission at Ames]

Mechanical analysis [2]—Continued										Liquid limit	Plasticity index	AASHO [3] classification
Percentage passing sieve—Continued						Percentage smaller than—						
⅜-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.			
										Percent		
100	98	94	83	74	52	42	30	17	11	39	15	A-6(5)
96	94	92	82	76	58	47	36	23	15	33	16	A-6(7)
100	98	94	86	80	63	56	38	22	15	28	13	A-6(7)
---------	100	99	95	91	80	68	50	32	24	41	18	A-7-6(11)
---------	---------	100	95	91	80	71	50	33	27	39	19	A-6(12)
99	99	98	93	90	82	75	51	32	27	40	22	A-6(13)

that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

[3] Based on AASHO Designation M 145–49 (*1*).

Engineering test data

Soil samples were taken, by horizons, from two series and tested according to standard AASHO procedures to help evaluate the soils for engineering purposes. The tests were made by the Iowa State Highway Commission. The data are given in table 5. Because the samples tested were obtained at a depth of 5 feet or less, they do not represent materials that are encountered at a greater depth.

The relationship between the moisture content and the density of compacted soil material, as determined by the test explained in AASHO Designation T 99-57 (*1*), is given in table 5 in the columns headed moisture-density. The density, or unit weight, of the compacted dry soil increases as the content of moisture increases until the optimum moisture content is reached. After that, the density decreases with each increase in moisture content. The highest density obtained in the test is at the optimum moisture content and is the maximum density. As a rule, optimum stability is obtained if the soil is compacted to about the maximum density when the soil is at or near the optimum moisture content.

The liquid limit and the plasticity index indicate the effect of moisture on the consistence of the soil material. As the moisture content of a dry, clayey soil is increased, the material changes from a semisolid state to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from the plastic to the liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Soil features affecting highway work [3]

Many of the soils in Guthrie County formed in loess over glacial till. The loess ranges from as much as about 20 feet thick on the nearly level soils on upland divides to a thin layer on the more sloping, dissected areas. In most places where slopes exceed about 15 percent, glacial till outcrops, and here the soils formed in glacial till. However, in the northern and northeastern parts of the county, where no loess overlies the glacial till, the soils also formed in glacial till.

The glacial till in Guthrie County has a relatively high in-place density. It is relatively stable at a normal moisture content and can be compacted readily to high density. The textural composition of the till varies, but when the material is dry there are enough fines and enough coarse material to provide a firm riding surface, with little rebound after loading. The glacial till has good bearing capacity when compacted to maximum density, but it loses this bearing capacity when moisture is absorbed.

The Sharpsburg, Macksburg, Ladoga, and Clinton soils are among those formed in loess. Their subsoil material is classified A-7 (CL or CH) and has high index numbers. Marshall soils also formed in loess and are also classified as A-7. Their index numbers are similar but typically somewhat lower. Macksburg soils have a fairly thick, organic surface layer. The soils that formed in loess tend to erode easily if runoff is concentrated. Sodding, paving, or check dams are needed in gutters and ditches to prevent excessive erosion.

In the soils that formed in loess, the seasonal high water table generally is above the contact line of the loess and the highly weathered glacial tills, which are often referred to as gumbotil. In the more nearly level areas, a seasonally perched water table is within a depth of 3 feet. In these areas the in-place density of the loess is relatively low and the moisture content is high. This high moisture content causes instability in embankments in places unless it is controlled enough to permit the soil to be compacted to high density.

The weathered Kansan till that underlies the loess in the more level areas is uniform and of poor quality for road construction. In the more sloping parts of the county, except those of the Clarion-Webster and Nicollet-Webster soil associations, these highly weathered glacial tills are on the surface. The Clarinda, Lamoni, Adair, and Armstrong soils formed in these materials. These soils have a plastic, highly weathered, silty clay or clay subsoil that is classified as A-7-6 (15-20). This layer is too expansive to be used for a highway subgrade and should not be used within 5 feet of the finished grade. If this clay material occurs at grade in roadcuts, it should be replaced with a backfill of less weathered glacial till, such as that found in the Shelby, Gara, and Lindley soils.

Below the clayey layer is a heterogeneous Kansan till that is classified primarily A-6 (CL). This till outcrops on the lower parts of slopes and is the parent material of Shelby, Gara, and Lindley soils. If this till is in or along grading projects, it generally is placed in the upper subgrade in unstable areas. The Clarion, Nicollet, Lester, and Storden soils in the Clarion-Webster and Nicollet-Webster soil associations formed in glacial till that was deposited in Wisconsin time. This till is predominantly A-4 or A-6 (CL), and can typically be compacted to high density with good bearing characteristics.

Pockets and lenses of sand commonly are interspersed throughout glacial till, and are seasonally water-bearing. Frost heaving is likely if the road grade is only a few feet above such sand deposits and the deposits are overlain by loess or loamy till. To prevent frost heaving, these deposits can sometimes be drained, or the soil above them can be replaced with a backfill of coarse, granular material or dense, clayey glacial till.

Webster and Canisteo soils formed in glacial sediments and glacial till. These soils, as well as the Nicollet soils, have a thick, dark-colored surface layer that is high in organic-matter content to a depth of about 2 feet and cannot be compacted to high density.

The soils on foot slopes or bottom lands formed in alluvium washed from hills on uplands. Soils, such as those of the Colo, Ely, Judson, Olmitz, Zook, Humeston, and Vesser series, have a thick, organic surface layer that consolidates erratically under an embankment load. Okoboji soils, formed from local alluvium in depressions in the glaciated upland, also are high in organic-matter content. These soils have low in-place density and high content of moisture. Therefore, if an embankment is to be more than 15 feet in height, these soils should be care-

[3] This section prepared by DONALD A. ANDERSON, soil engineer, Iowa State Highway Commission.

fully analyzed to be sure that they are strong enough to support it. Nodaway soils, although low in organic-matter content, are stratified and have lenses of loamy sand in places. An embankment constructed only a few feet above the water table on these soils may be damaged by frost heaving in places. Roadways through bottom lands should be constructed on a continuous embankment that extends above the flood level.

Waterworn gravel is present in deposits of glacial outwash that underlie such soils as those of the Cylinder and Wadena series. The same is true of Salida soils. These deposits are sources of high-quality material for construction. Dickinson soils that are in a complex with Sharpsburg soils in Guthrie County are sandy in the substratum and very erodible. Roadway slopes in these soils should be protected from soil blowing and erosion by a ground cover.

Some soils in Guthrie County formed in residual materials. Beds of sandstone and shale crop out along a number of major and minor streams. Hesch and Montieth soils formed in material weathered from weakly cemented sandstone. These soils are erodible in cuts. Gosport and Clanton soils formed in material weathered from shales. These shales contain thin lenses of sandstone, limestone, and coal. Unless care is taken in these places, the soil above the shale slides if the natural slope is disturbed in construction.

Formation and Classification of the Soils

This section consists of three main parts. In the first part, the factors of soil formation are listed and discussed as they relate to the formation of soils in the county. The second part discusses the formation of soil horizons and the processes of their formation. In the third part, each soil series represented in the county is placed in its respective family, subgroup, and order in the current system for classifying soils. Detailed descriptions of soil profiles considered representative of the series are given in the section "Descriptions of the Soils." This section is useful for scientists, teachers, students, and others interested in the formation and classification of soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent materials, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil formation have acted on the soil material. These characteristics and also man's influence on the soils are discussed in this section.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is need for the changing of the parent material into a soil profile. It may be a long or short time, but some time is always required for horizon differentiation. Generally a long time is required for the development of distinct horizons.

The factors of soil genesis are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

The soils of Guthrie County formed in loess, glacial till, alluvium, shale, sandstone, and eolian sand. These parent materials are discussed briefly. Those interested in a more detailed discussion can refer to some of the publications listed in the Literature Cited. The relationship of some of the major soils to their parent materials is shown in figure 13.

Glacial till is the most extensive soil parent material in the county. Three glaciers have deposited material in Guthrie County—the Nebraskan, the Kansan, and the Wisconsin. The first till to be deposited, the Nebraskan, has been buried by the Kansan till and is not identifiable on the landscape. The Kansan till is exposed in all parts of the county, except the northeastern part, and is the major parent material in the Gara-Lindley association. The unweathered Kansan till is a firm, calcareous clay loam. It contains pebbles, boulders, and sand as well as silt and clay. The till is a heterogeneous mixture and shows little evidence of sorting or stratification. The mineral composition of its components is also heterogeneous (*13*) and is similar to that of particles in unweathered loess.

Soils formed on the Kansan till plain during the Yarmouth and Sangamon interglacial period before the loess was deposited (*25*). The soils formed during this period are called Yarmouth-Sangamon paleosols. In nearly level areas the soils are strongly weathered and have a gray, plastic subsoil called "gumbotil" (*11, 12, 17*). This gumbotil is several feet thick and is very slowly permeable. Widespread erosion has cut below the Yarmouth-Sangamon paleosol into Kansan till and older deposits. The surface is characterized generally by a stone line or subjacent sediment and is surmounted by pedisediment (*2, 19*). A paleosol formed in the pedisediment, stone lime, and generally the subjacent till (*18*). This surface is referred to as Late Sangamon. The paleosols were less strongly weathered, more reddish in color, and not so thick as those on nearly level areas.

The soils formed in the Kansan till during Yarmouth and Sangamon time were covered by loess. Geologic erosion has removed the loess from many slopes and has exposed these paleosols. In some places the paleosols have been beveled or truncated, so that only the lower part of the strongly weathered paleosols remains. This erosion took place prior to loess deposition, or before about 25,000 years ago. In other places, erosion has removed all of the paleosol and has exposed till that is only slightly weathered at the surface. This erosion took place mostly in postglacial times.

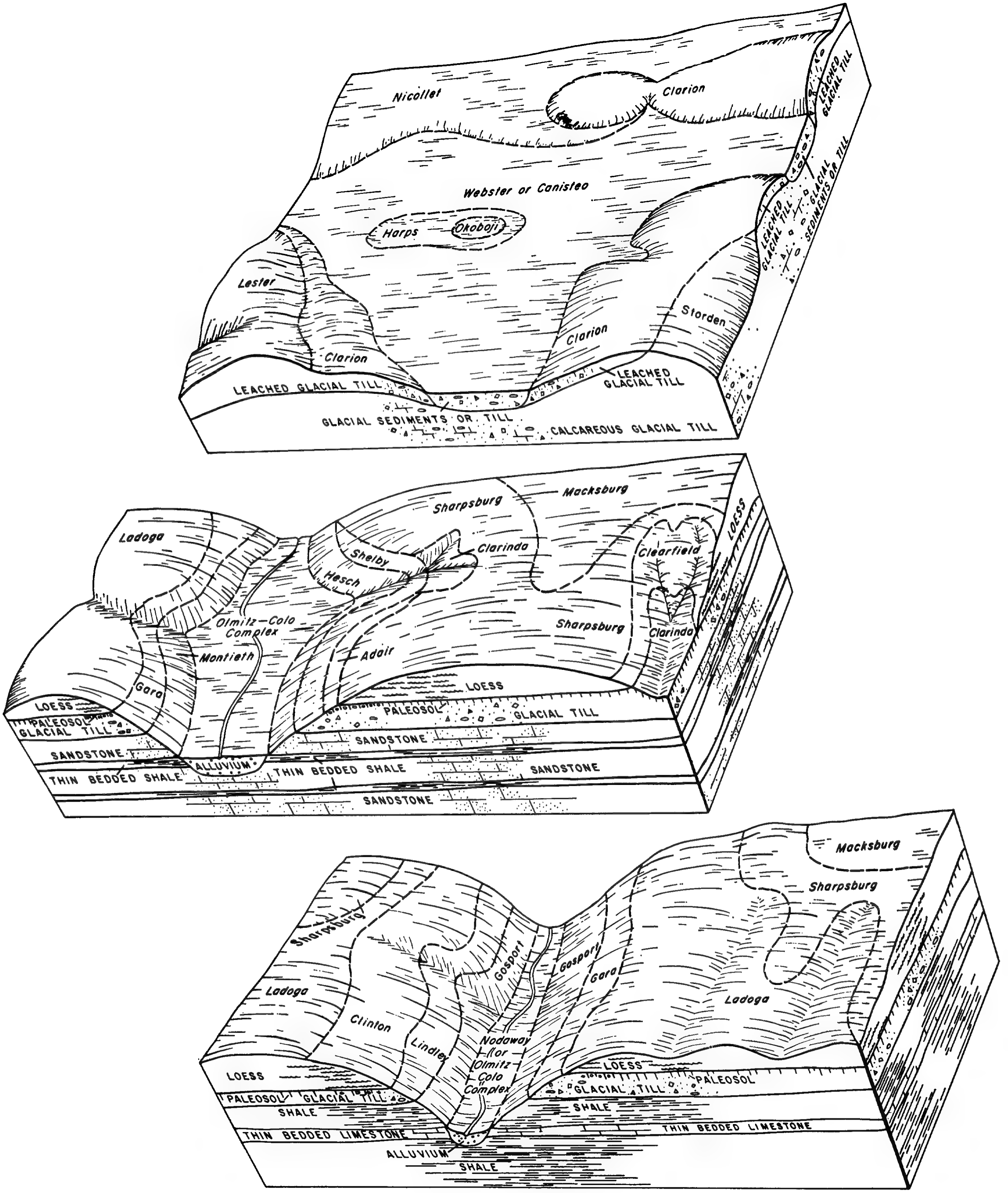

Figure 13.—Relationship of soils to topography and parent material. *Top,* soils in the northeastern part of the county; *middle,* soils in the central part of the county; *bottom,* soils in the southeastern part of the county.

The Clarinda soils formed in the strongly weathered Yarmouth-Sangamon gray, clay paleosol. Lamoni soils formed in the truncated Yarmouth-Sangamon paleosol. Their clay layer is not so thick as in the Clarinda soils. The Adair and Armstrong soils formed where the less strongly sloping, weathered, reddish paleosol outcrops. The Shelby, Gara, and Lindley soils formed in a slightly weathered glacial till that has had the overlying paleosols removed by geologic erosion.

The northeastern part of the county, north and east of the Middle Raccoon River, was covered by the Des Moines lobe of the Wisconsin Glaciation. The till, which is the parent material for most of the soils in this part of the county, was deposited by the Cary substage of the Wisconsin Glaciation (*21*, *24*). Radiocarbon dates from the base of the till in the southern part of the lobe indicate that this glaciation occurred about 14,000 years ago. One evidence of the geologic youth of the Cary substage is the poorly developed surface drainage system and numerous closed depressions. The major soils that formed in Cary till are of the Clarion, Storden, and Nicollet series. The Webster and Harps soils formed in glacial till and in glacial sediments or reworked glacial till over glacial till (*38*, *39*). The Okoboji soils formed in reworked glacial till and local alluvium.

In parts of Victory, Cass, and Jackson Townships are areas north of the Middle Raccoon River where the Cary till, or sediments from it, appear to be very thin over a clay loam till that resembles the Kansan till. About 500 acres of a gently sloping Shelby soil was mapped in this area. The upper part of the profile of this soil is similar to that of Clarion soils, and the lower part is similar to that of Shelby soils as they occur in other parts of the county. Some areas of Shelby soils on steeper slopes were also mapped in these areas, but they are minor in extent. Soils that were included with Nicollet and Webster soils were also mapped in these areas. They are underlain by firm clay loam till that is not typical of Nicollet and Webster soils in other places.

Loess is the second most extensive parent material in the county. It is a yellowish-brown, wind-deposited material that consists largely of silt particles. It contains smaller amounts of clay and sand. Loess was deposited during the Wisconsin glacial period from about 24,500 to 14,000 years ago (*23*). The loess is believed to have been blown mainly from the flood plain of the Missouri River along the western side of Iowa (*8*). The thickness of the loess and the differences between soils formed in loess are related to the distance from the source of the loess. The loess is thickest in Guthrie County in the northwestern part, where the Marshall soils occur. It is about 12 to 18 feet thick on the most stable parts of the uplands. Most areas of the county where loess occurs are on these uplands. The loess is thinner on side slopes, however, and on all or part of most side slopes, all of the loess has been removed by erosion and glacial till is exposed on the surface.

The loess of southwestern and southern Iowa gradually thins and becomes finer textured from west to east. The Marshall soils in the northwestern part of the county are somewhat lower in clay content than the similar Sharpsburg soils east and south of them.

Sharpsburg and Ladoga soils are the most extensive of the soils in Guthrie County that formed from loess. Macksburg, Marshall, Clinton, and Clearfield soils are less extensive. The loess and the soils formed in loess in western and southwestern Iowa have been the subject of much study and investigation (*3*, *4*, *7*, *16*, *20*, *26*, *32*, *33*, *36*).

Alluvium consists of sediments deposited along major and minor streams and drainageways. It also is on benches. The texture of the alluvium varies widely because of differences in materials from which it came and the manner in which it was deposited. In Guthrie County the main sources of alluvium have been loess, glacial till, outwash deposited by melt water from glaciers, and layers of exposed shale and sandstone bedrock.

Some of the alluvial material has been transported only short distances and is called local alluvium. Such alluvium retains many of the characteristics of the soils from which it has washed. Judson soils, for example, generally are at the base of slopes below soils formed in loess. They are silty and similar in texture to the soils upslope. The Olmitz soils also have formed in local alluvium, but they are generally downslope from till-derived soils. They contain more sand than Judson soils because the alluvium in which they formed came from sandier soils. The Ely soil is another soil that formed in local alluvium.

The coarse-textured, sandy deposits are deposited first adjacent to the stream when the rivers and streams overflow their channels. As the water spreads outward toward the uplands it moves more slowly. Generally, the farther from the stream channel, the finer the particles that are deposited, and the finer textured the soils that occur there.

This pattern is demonstrated many times on the wider stream bottoms in the county. If Alluvial land occurs, it is nearest the streams. Next are the Spillville, Nodaway, and Kennebec soils. Colo and Zook soils are farthest from the main channel. These are the finest textured, most poorly drained of these soils, and they commonly are somewhat lower in elevation than the other soils.

Along the larger streams in the county, especially the South Raccoon River, the Nevin and Vesser soils formed in silty alluvium on low stream benches or second bottoms. These alluvial soils have more profile development and are not so subject to flooding as the alluvial soils on first bottoms.

The Wadena and Cylinder soils are in the northeastern part of the county. These soils are on benches along streams. They formed in about 24 to 40 inches of loamy alluvium overlying sand and gravel. These materials were deposited by melt waters from the receding Cary glacial ice.

Sandstone and shale are the oldest parent material in the county. They occur as a series of beds deposited during the Cretaceous and Pennsylvanian periods (fig. 14). These beds consist mainly of sandstone and shale. A few outcroppings of limestone, conglomerates, and organic layers, such as coal, are also present, but they are not extensive in Guthrie County.

Gosport soils formed in grayish shale that is many feet thick. These soils are mainly on the lower parts of side slopes that border the South Raccoon River in Penn, Stuart, Beaver, and Jackson Townships. In the same area and in similar positions, Clanton soils formed in reddish shale. Other soils that formed in shale in the southern

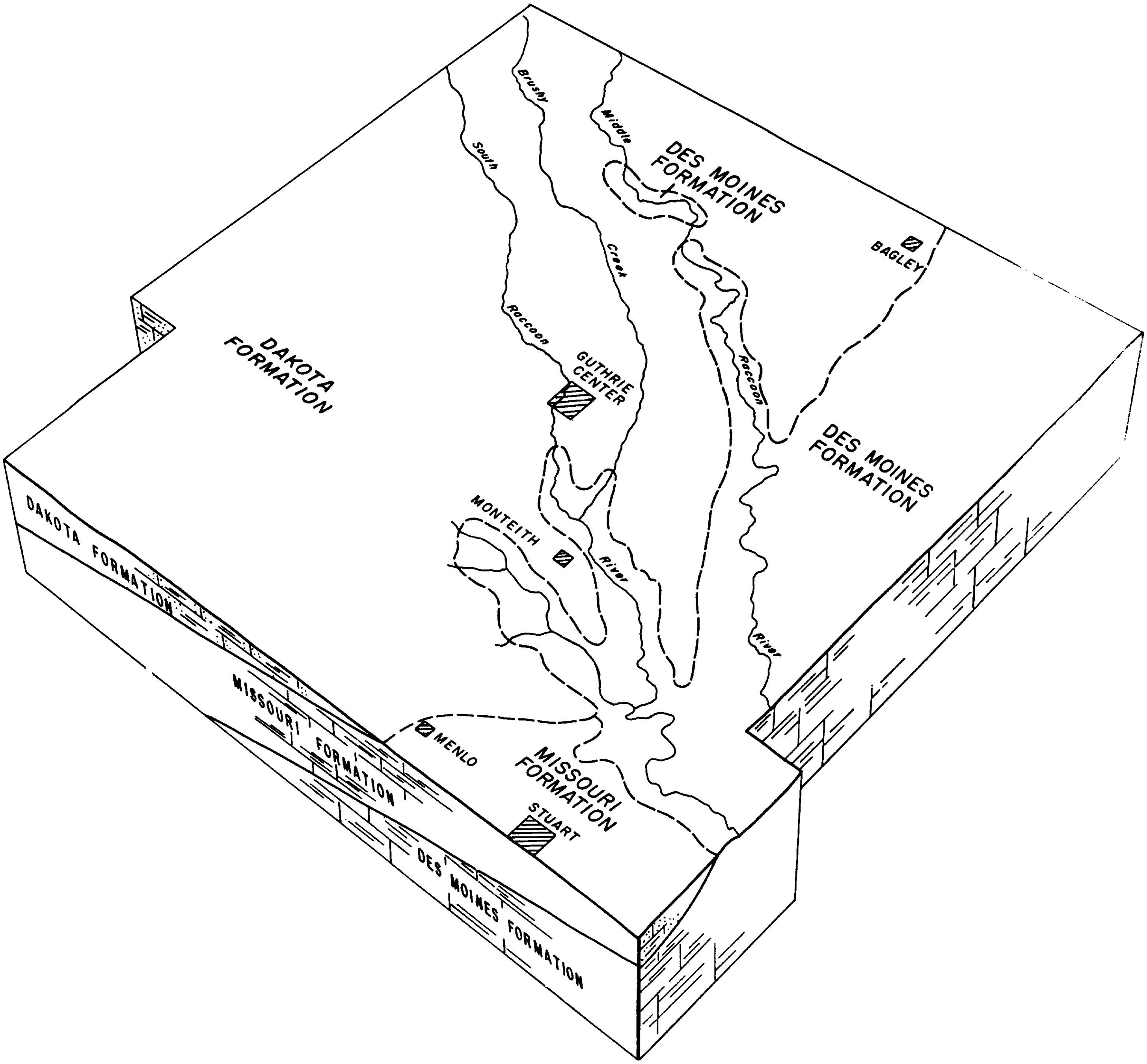

***Figure 14.*—Location and extent of bedrock formations in Guthrie County.**

part of Iowa have a wide range in texture, reaction, and other characteristics.

Eolian sand is a very minor parent material in Guthrie County. This sand was deposited by winds during the same period of time as the loess. Apparently there were sources, probably nearby stream bottoms, from which the sand was picked up and redeposited.

The Dickinson soils are the only soils in the county that formed in this material. These soils are mainly in small areas surrounded by loess soils, and in Guthrie County they are in the Dickinson-Sharpsburg complexes.

Climate

Soils in Guthrie County, according to recent evidence, formed under variable climatic conditions. In the post-Cary glaciation period, from about 13,000 to 10,500 years ago, the climate was cool and the vegetation was dominantly conifers. During the period from 10,500 to 8,000 years ago, a warming trend occurred, and the vegetation changed from conifers to mixed forest, dominantly hardwoods. Beginning about 8,000 years ago, the climate became warmer and drier, and herbaceous prairie vegeta-

tion became dominant. About 3,000 years ago, a late change in postglacial climate from relatively dry prairie to more moist conditions began to take place (*14*, *38*). The present climate is midcontinental subhumid.

Nearly uniform climate prevails throughout the county, although there is some variation in rainfall from west to east. The influence of the general climate is modified by local conditions in or near the developing soil. For example, south-facing slopes have a microclimate that is warmer and less humid than the average climate of nearby areas. North- and east-facing slopes tend to be cooler and more moist than south-facing slopes, and in a climate such as that in Guthrie County, natural stands of trees are more likely to grow. Low-lying or depressional, poorly or very poorly drained soils are wetter and colder than most soils around them.

The general climate has had an important overall influence on the characteristics of the soils but has not caused major differences among them. The local climate differences influence the characteristics of the soils and account for some of the differences in soils within the same climatic region.

Weathering of the present material by water and air is activated by changes in temperature. As a result of weathering, changes caused by both physical and chemical actions take place. Rainfall has influenced the formation of the soils through its effect on the amount of leaching in soils and on the kinds of plants that have grown.

Some variations in plant and animal life are caused by a variation in temperature or by the action of other climatic forces on the soil material. To that extent, climate influences changes in soils that are brought about by differences in plant and animal variations.

Plant and animal life

A number of kinds of living organisms are important in soil development. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, are reflected in soil properties. Differences in the kind of vegetation commonly cause the most marked differences between soils (*15*, *40*).

The preceding subsection discusses the fact that the dominant kinds of plant life have changed with time. The soils of Guthrie County appear to have been influenced in recent times by two main types of vegetation: prairie grasses and trees.

In Guthrie County, tall prairie grasses were the dominant vegetation at the time of settlement. However, trees were near most major streams and their larger tributaries. Trees occupied about 44,000 acres at the time of settlement.

Because grasses have many roots and tops that have decayed in or on the soil, soils formed under prairie vegetation typically have a thicker, darker colored surface layer than do soils that formed under trees. In soils formed under trees the organic matter, derived principally from leaves, was deposited mainly on the surface layer. Soils that formed under trees generally are more acid and have more downward movement of bases and clay minerals in the profile than soils that formed under prairie.

The Sharpsburg and Macksburg soils are typical of those formed in loess under prairie vegetation, and Clarion, Nicollet, and Shelby soils are typical of those formed in glacial till. Very poorly drained soils, such as those of the Okoboji series, formed under a native vegetation of sedges, cattails, and other vegetation tolerant to wetness.

The Clinton and Lindley soils are among those in Guthrie County that formed under forest vegetation. Clinton soils formed in loess, and Lindley soils formed in glacial till. These soils have a thin, light-colored A1 horizon, a prominent, grayish-brown A2 horizon that is very distinct when dry, and a B horizon that has a stronger structure and more evidence of the accumulation of silicate clay than in soils formed under prairie grasses.

Ladoga and Gara soils, however, have properties intermediate between those formed entirely under trees and those formed under grass. It is believed that these soils formed under prairie and then later trees grew in the area. Their morphology reflects the influence of both trees and grass.

Relief

Relief, or topography, refers to the lay of the land. Soils range from nearly level to very steep in Guthrie County. Relief is an important factor in soil formation because of its effect on drainage, runoff, the height of the water table, and erosion. A difference in topography is the main reason for the differing properties of some of the soils in the county. This influence can be seen in a number of ways in Guthrie County.

The thickness and color of the A horizon and the thickness of the solum are related to slope because of its effect on erosion and the amount of water that runs off and percolates through the soil. For example, the thickness and color of the A horizon of the Storden, Clarion, and Nicollet soils, which formed in similar parent material, are related to their topography. The thickness of the A horizon increases and the color darkens as the slope decreases. Most areas of Storden soils are strongly sloping to steep, Clarion soils are mainly gently or moderately sloping, and Nicollet soils are nearly level. The thickness of the solum increases and depth to carbonates decreases from the thinner Storden soil to the increasingly thicker Clarion and Nicollet soils. On soils similar to Shelby soils, which have a wide range of slopes, the depth to carbonates and the thickness of solum are shallower as the percentage of slope increases and the slopes are more convex in nature.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. The subsoil of a soil that has good drainage generally is brown because iron compounds are well distributed throughout the horizon and are oxidized. On the other hand, the subsoil of soils that have restricted drainage or poor aeration caused by wetness and a high water table is generally grayish and mottled. Webster and Okoboji soils are examples of poorly drained and very poorly drained, nearly level and depressional soils in which the evidence of wetness is expressed in the soil profile. Sharpsburg soils are moderately well drained, sloping soils that have a brownish B horizon. Macksburg soils are somewhat poorly drained and are grayish brown in the subsoil. Their profile characteristics indicate that they are intermediate in drainage.

The water that percolates through soils removes clay from the A horizon, and much of this clay accumulates in the B horizon. Generally, in soils formed in similar

parent material under similar vegetation, those soils on nearly level areas or in depressions have more water percolating through the profile than those on slopes, where part of the water runs off. Generally, the percentage of clay in the B horizon is progressively greater on the sloping to nearly level or depressional soils. This is not well illustrated by a complete sequence of soils in Guthrie County; the sloping Sharpsburg soils, however, contain less clay than the nearly level Macksburg soils (*9*).

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in parent material. Very similar kinds of soils are formed in widely different kinds of parent material if other factors continue to operate over long periods of time. Soil development, however, is generally interrupted by geologic events that expose new material. In Guthrie County, new parent material has been added to the upland at least three times in most of the county and four times in the northeastern part (*30*). In all parts of the county, the bedrock was first covered by glacial drift from two different glaciers and then loess was deposited. In the northeastern part of the county, another glacier subsequently deposited the present surface material.

The Clarinda and Lamoni soils have a subsoil that is among the most weathered in the county. These soils formed in Kansan till that began to weather in Yarmouth and Sangamon times. Then they were covered by loess. More recently, the upper, ancient subsoil material has been exposed to weathering again when the loess was removed by erosion. Even older are beds of shale and sandstone that are below the glacial till. These also have been exposed on the landscape. Here Gosport, Hesch, and Montieth soils formed. These soils vary considerably in the degree to which they have weathered.

The radiocarbon technique for determining the age of carbonaceous material found in loess and till has been useful in dating late Pleistocene events (*22*). Loess deposition began about 25,000 years ago and continued to about 14,000 years ago (*6*). Based on these dates, the surface of nearly level, loess-mantled divides in Iowa is about 14,000 years old. In Guthrie County these stable areas include the nearly level soils and most of the gently sloping soils in divides. They are mainly the Sharpsburg, Ladoga, and Macksburg soils. Radiocarbon dates from the base of the Cary glacial drift in the southern part of the Des Moines lobe have indicated that it was deposited about 14,000 years ago. Thus, all soils formed in it are as young or younger than 14,000 years old. In much of Iowa, including Guthrie County, geologic erosion has beveled and, in places, removed material on side slopes and deposited new sediments downslope. The surface layer of nearly level soils on upland divides is older than that on the slopes that bevel and ascend to the divides. Thus, the soils on side slopes are less than 14,000 years old. In Guthrie County Shelby, Gara, Clarion, and Lindley soils are on side slopes.

The sediment stripped from side slopes accumulated to form local alluvium. The age of soils on side slopes is determined by dating the alluvial fill at the base of slopes, which in some stream valleys in western Iowa is less than 1,800 years old. Some of the soils that formed in alluvium in Guthrie County are those of the Ely, Kennebec, Olmitz, Judson, and Colo series. Nodaway soils formed in alluvium, some of which has been deposited since settlement by man.

Man's influence on the soils

Important changes have taken place in the soils since Guthrie County was settled. Breaking of the prairie sod and clearing of the timber removed and changed the protective cover.

The most apparent changes are those caused by erosion. As the soil was cultivated, surface runoff increased and the rate at which water moved into the soil decreased. This resulted in accelerated erosion that has removed part or all of the surface layer from much of the cultivated, sloping soils. In some places, shallow to deep gullies formed.

Erosion has changed not only the thickness of the surface layer, but the structure and consistence as well. In severely eroded areas, the plow layer often consists partly of the upper part of the subsoil, which is less friable and finer textured than the original surface layer.

Erosion and cultivation also affect the soil by reducing the organic-matter content and lowering the fertility of the soil. Even in areas not subject to erosion, compaction by heavy machinery reduces the thickness of the surface layer and changes its structure. The granular structure, so apparent in virgin grassland, breaks down under intensive cultivation.

On the other hand, man can and has done much to increase productivity, decrease soil loss, and reclaim areas not suitable for crops or pasture. For example, terraces, erosion control structures, and other erosion control practices have slowed and, in some places, controlled runoff and erosion. The establishment of diversion terraces at the base of slopes and drainage ditches and other practices have aided in the prevention of flooding and deposition and have made large areas of bottom land suitable for cultivation.

Through the use of commercial fertilizers and lime, the deficiencies in plant nutrients are corrected so that many soils are more productive than they were in the virgin state.

Erosion is one of the main causes of the reduction of organic matter in soils. However, figures indicate (*31*) that as much as one-third of the organic matter can be lost by causes other than erosion. Management practices have shown that it is not economically feasible to maintain as high a reserve of organic matter as was originally present under native grasses. It is necessary, however, to maintain a safe and economical level for crop production. In soils lowest in organic matter, this is done by control of erosion.

Processes of Soil Horizon Differentiation

Horizon differentiation is caused by four basic kinds of changes. These are additions, removals, transfers, and transformations in the soil system (*28*). Each of these four kinds of changes affects many substances that make up soils. For example, there are additions, removals, transfers, or transformations of organic matter, soluble salts, carbonates, sesquioxides, or silicate clay minerals.

In general these processes tend to promote horizon differentiation, but some tend to offset or retard it. These

processes, and the changes brought about by them, proceed simultaneously in soils, and the ultimate nature of the profile is governed by the balance of these changes within the profile.

Additions of organic matter are an early step in the process of horizon differentiation in most soils. Soils in Guthrie County range from high to very low in organic-matter content that has accumulated in the A1 horizon. Clinton and Lindley soils, for example, have a thin A1 horizon and are low in organic-matter content. Webster and Colo soils are among those that have a thick A1 horizon and are high in organic-matter content. Some soils that were formerly high in organic-matter content are now low because of erosion.

The removal of substances from parts of the profile is important in the differentiation of soil horizons in Guthrie County. Most of the soils in the county have been leached free of calcium carbonates in the upper part of the profile, and some have been so strongly leached that they are strongly acid or very strongly acid in the surface layer and subsoil. The Harps, Canisteo, and Storden soils are exceptions and are calcareous throughout.

A number of kinds of transfers of substances from one horizon to another are evident in the soils of Guthrie County. Phosphorus is removed from the subsoil by plant roots and transferred to parts of the plant growing above the ground. Then it is added to the surface layer in the plant residue.

The translocation of clay is an important process in horizon differentiation. The clay, composed primarily of silicate clay minerals in this area, is carried downward in suspension in percolating water from the A horizon. It accumulates in the B horizon in pores and root channels and as clay films on ped faces.

Another kind of transfer that occurs to some extent in clayey soils, is that brought about by shrinking and swelling. This causes the formation of cracks and the incorporation of some materials from the surface layer into the lower parts of the profile. Clarinda soils are examples of soils that have a potential for this kind of physical transfer.

Transformations are physical and chemical. For example, soil particles are weathered to smaller sizes. The reduction of iron is another example of a transformation. This process is called gleying and involves the saturation of the soil with water for long periods in the presence of organic matter. It is characterized by the occurrence of ferrous iron and gray colors. Reductive, extractable iron, or free iron, is generally at a greater depth in poorly drained soils than in soils such as Macksburg and Sharpsburg soils. Still another kind of transformation is the weathering of the primary apatite mineral present in the parent material to secondary phosphorus compounds.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

The system of classifying soils currently used by the National Cooperative Soil Survey was developed in the early sixties (*29*) and was adopted in 1965 (*35*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 6 shows the classification of each soil series in Guthrie County by family, subgroup, and order, according to the current system.

ORDERS.—The ten soil orders recognized are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, the Entisols and Histosols, occur in many different climates.

The four orders found in Guthrie County are Alfisols, Entisols, Inceptisols, and Mollisols. Alfisols have clay-enriched B horizons that are high in base saturation. Entisols do not have genetic horizons or have only weakly expressed beginnings of such horizons. Inceptisols have one or more diagnostic horizons that are thought to form rather quickly and do not represent significant illuviation or eluviation or extreme weathering. They are young soils. Mollisols have a thick, soft, friable surface layer that has been darkened by organic matter.

SUBORDERS.—Orders are subdivided into suborders, primarily on the basis of those characteristics that seem to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or the absence of waterlogging, or soil differences resulting from the climate or vegetation.

GREAT GROUPS.—Soil suborders are separated into great groups on the basis of uniformity in kind and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated, or those that have pans that interfere with the growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like.

SUBGROUPS.—Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order.

FAMILIES.—Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are tex-

TABLE 6.—*Soil series classified according to the current system of classification*

Series	Family	Subgroup	Order
Adair	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Armstrong	Fine, montmorillonitic, mesic	Aquollic Hapludalfs	Alfisols.
Calco	Fine-silty, mixed (calcareous), mesic	Cumulic Haplaquolls	Mollisols.
Canisteo	Fine-loamy, mixed (calcareous), mesic	Typic Haplaquolls	Mollisols.
Clanton	Fine, illitic, mesic	Mollic Hapludalfs (Paleudalfs)	Alfisols.
Clarinda	Fine, montmorillonitic, mesic, sloping	Typic Argiaquolls	Mollisols.
Clarion	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Clearfield	Fine-silty, mixed, mesic, sloping	Typic Argiaquolls (Haplaquolls)	Mollisols.
Clinton	Fine, montmorillonitic, mesic	Typic Hapludalfs	Alfisols.
Colo	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Cylinder	Fine-loamy over sand or sandy-skeletal, mixed, mesic	Aquic Hapludolls	Mollisols.
Dickinson	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Ely	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Gara	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Gosport	Fine, illitic, mesic	Typic Dystrochrepts	Inceptisols.
Harps	Fine-loamy, mesic	Typic Calciaquolls	Mollisols.
Hesch [1]	Coarse-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Humeston	Fine, montmorillonitic, mesic	Argiaquic Argialbolls	Mollisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Ladoga	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols.
Lamoni	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Lester	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Lindley	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Macksburg	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Marshall	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Montieth	Sandy, mixed, mesic	Psammentic Hapludalfs	Alfisols.
Nevin	Fine-silty, mixed, mesic	Aquic Argiudolls (Hapludolls)	Mollisols.
Nicollet	Fine-loamy, mixed mesic	Aquic Hapludolls	Mollisols.
Nodaway	Fine-silty, mixed, nonacid, mesic	Typic Udifluvents	Entisols.
Okoboji	Fine, montmorillonitic, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Olmitz	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Salida	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols.
Sharpsburg	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Shelby	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Spillville	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Storden	Fine-loamy, mixed (calcareous), mesic	Typic Udorthents	Entisols.
Vesser	Fine-silty, mixed, mesic	Argiaquic Argialbolls	Mollisols.
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic, (coarse-loamy).	Typic Hapludolls	Mollisols.
Webster	Fine-loamy, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Zook	Fine, montmorillonitic, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.

[1] The soils are taxadjuncts to the Hesch series because they are coarse-loamy rather than fine-loamy in the upper horizons.

ture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. An example is the fine, montmorillonitic, mesic family of Typic Argiudolls.

SERIES.—The series consists of a group of soils that formed in a particular kind of parent material and that have genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

Some of the soils in this county do not fit in a series that has been recognized in the classification system, but recognition of a separate series would not serve a useful purpose. Such soils are named for series they strongly resemble and from which they differ in ways too small to be of consequence in interpreting their usefulness or behavior. These soils are taxadjuncts to the series for which they are named. In Guthrie County the Hesch soils are taxadjuncts to that series.

General Nature of the County

This section was prepared for those who are not familiar with the county. It discusses the history and development, farming, vegetation, topography and drainage, and climate of Guthrie County.

History and Development

Guthrie County was legally organized in 1851. Panora, the first settlement, was the county seat from 1859 to 1860 and from 1862 to 1873. Guthrie Center has been the county seat in all other years.

The first permanent settler came from Wapello County, Iowa in the fall of 1848. Fifteen years later the population was 3,000, and by 1880 the population had increased to 14,000.

In the early years the county was crossed by the Western Stage Company. Railroad service started when

the Rock Island station at Stuart opened in September of 1868, and local rail lines now run to most of the larger towns in the county. Bus service is also available in the county, and scheduled airline flights are obtainable at Des Moines, 54 miles east of Guthrie Center.

State Routes 141 and 64 and U.S. Highway No. 6 cross the northern, middle, and southern parts of the county from east to west, respectively. Interstate Highway 80 passes through adjoining Adair County near the county line on the south. Gravelled or blacktop roads serve most farm homes in Guthrie County.

Farming

In 1966 the total area in farms in Guthrie County was 368,607 acres (*10*). Most of this acreage was used for crops, but 116,540 acres were used for pasture. Another 23,181 acres were in woodland or wasteland, and 34,169 acres were idle.

Corn is the main crop in the county, and the second most important crop is soybeans. The 92,043 acres of corn harvested for grain in 1966 yielded an average of 81.9 bushels per acre; the 47,445 acres in soybeans yielded an average of 28.4 bushels per acre; and the 17,082 acres in oats yielded 53.3 bushels per acre. Hay of all types was planted on 33,570 acres.

Although a few cash-grain farms, especially in the northeastern part of the county, receive most of their income from corn and soybeans, most farm income is from livestock sales. Beef cattle and hogs sold account for most of the livestock in Guthrie County. In 1966 there were 25,799 grain-fed cattle sold. Sows farrowed totaled 21,328, and 22,221 calves and 3,849 lambs were born. The county had 20,656 beef cows and 3,280 milk cows. There were also 127,741 laying hens and 26,406 commercial broilers.

Many of the cattle and hogs are trucked to market in Omaha, and some are sent to Chicago. Some are also marketed at nearby Iowa packing plants at Perry, Oakland, and Denison. Eggs are picked up by route men from local produce houses. Milk and cream are hauled to creameries and dairies in a number of towns, mostly outside the county. Corn and soybeans are mainly purchased by local grain dealers and trucked to larger terminal grain markets.

In recent years Guthrie County has had a steady decrease in the number of farms and an increase in the size of farms. In 1966 there were 5,398 people living on 1,555 farms. The average farm was 237 acres in size, and 53.2 percent of the land was owned by farm operators. Tenants operated 46.8 percent of the farmland.

Vegetation

The native vegetation of Guthrie County consists mainly of prairie grasses (bluestems) and oak-hickory type forest. Prairie grasses were dominant in three separate areas. The largest area is in the northern third of the county, north and east of a line running from Linden through Panora and Springbrook State Park to Coon Rapids. The second area parallels the west county line, west of a line from Adair to Coon Rapids. The smallest area is in the southeastern corner of the county in the area surrounding the towns of Stuart and Menlo. The area around Sheeder Prairie State Park west of Guthrie Center is about the only example of native prairie vegetation remaining undisturbed in the county.

Forest was the dominant native vegetation along the major streams in Guthrie County. The largest area is a 2-mile belt on either side of the Middle Raccoon River. Small, isolated areas of woods are along the South Raccoon River and Deer, Beaver, Mason, and Frost Creeks. Nearly all of the original stands of timber have been cut (*5*).

Topography and Drainage

Guthrie County has two topographically different areas. The area north and east of the Middle Raccoon River, covering about a fourth of the county, has the undulating, nearly level to gently rolling topography typical of the Wisconsin drift area. It has few natural drainageways and many enclosed depressions. The rest of the county has a more rugged relief and a dense drainage pattern. The large streams have well-developed tributaries fed by numerous smaller streams. Slopes range from gently sloping near the smaller tributaries to very steep near the large valleys.

The bottom lands and benches along the North and South Raccoon Rivers and Brushy Creek are nearly level. An area 2 to 3 miles wide in Stuart and Beaver Townships is a nearly level to gently rolling upland divide.

All of the major streams are in the southwestern three-fourths of the county. Mosquito Creek and Bay Branch are the only major drainageways in the northeastern fourth of the county.

The Middle and South Raccoon Rivers start in the northwestern part of the county and run parallel to each other to the southeastern corner of the county. Brushy Creek runs between the two Raccoon Rivers and flows into the South Raccoon River near Montieth.

The western part of the county is drained to the west by Troublesome Creek and smaller creeks that start in that area. These drainageways flow toward the Missouri River.

Drainage in the southwestern three-fourths of the county is generally adequate, except for low river bottom lands and a broad upland divide near Stuart in the southeastern part of the county. Large areas of the northeastern fourth of the county have inadequate natural drainage. In this area tile lines and artificial drainageways are common.

Climate [4]

Guthrie County, in the west-central part of Iowa, is mostly drained by the Raccoon River. Guthrie Center, centrally located along the South Raccoon River, has representative weather for Guthrie County. The weather data for tables 7 and 8 are recorded at this site.

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[4] Prepared by PAUL J. WAITE, climatologist for Iowa, National Weather Service, United States Department of Commerce.

TABLE 7.—*Temperature and precipitation*

[Data recorded at Guthrie Center, Iowa]

Month	Temperature: Average daily maximum	Temperature: Average daily minimum	Temperature: Average monthly maximum	Temperature: Average monthly minimum	Precipitation: Average monthly total	Precipitation: One year in 10 will have: Less than—	Precipitation: One year in 10 will have: More than—	Precipitation: Days with snow of 1 inch or more	Precipitation: Average depth of snow on days with snow cover
	°*F.*	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*	*Days*	*Inches*
January	31	12	52	−12	1.0	0.5	2.2	16	5
February	35	15	54	−8	1.0	.1	1.9	12	5
March	47	25	72	4	1.9	.6	3.9	8	6
April	62	38	83	22	2.3	.7	4.4	1	3
May	73	49	89	33	3.8	.7	6.7	0	
June	82	59	95	45	4.7	1.9	7.8	0	
July	87	63	99	52	3.6	1.0	6.5	0	
August	85	61	94	48	4.4	1.2	8.7	0	
September	77	53	89	34	3.1	.7	5.7	0	
October	66	41	84	23	2.0	.4	4.9	0	
November	49	28	70	7	1.7	.1	4.3	3	3
December	35	17	55	−6	1.0	.1	2.0	10	3
Year	61	38	100	−16	30.5	22.8	39.6	50	5

TABLE 8.—*Probabilities of freezing temperatures in spring and in fall*

Probability	Dates for given probability and temperature: 16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 not later than	March 7	March 20	March 27	April 10	April 15
3 years in 10 not later than	March 16	March 29	April 4	April 19	April 27
5 years in 10 not later than	March 23	April 5	April 11	April 25	May 3
7 years in 10 not later than	March 30	April 12	April 18	May 1	May 9
9 years in 10 not later than	April 8	April 22	April 26	May 10	May 18
Fall:					
1 year in 10 earlier than	October 31	October 19	October 10	October 5	September 20
3 years in 10 earlier than	November 8	October 28	October 20	October 15	September 29
5 years in 10 earlier than	November 15	November 4	October 27	October 21	October 5
7 years in 10 earlier than	November 22	November 11	November 3	October 27	October 11
9 years in 10 earlier than	November 31	November 20	November 12	November 5	October 20

Annual precipitation averages from 30 inches in the northwestern part to over 31 inches in the southeastern townships. About 72 percent of the annual precipitation falls during April through September. About 100 days per year have measurable precipitation; of these, 56 have 0.10 inch or more and 18 have 0.50 inch or more. Most of the heavy rainfall that causes soil erosion occurs during the season when soil is not frozen and is under tillage. The maximum erosion and soil blowing potential is late in spring and early in summer before most planted crops are well rooted and when ground cover is sparse. Showers vary greatly in erosion potential because of their local nature. About 10 percent of the annual precipitation falls as snow, totaling about 30 inches, and occurring from November to April.

Ideally, at crop planting time soils have ample moisture in the subsoil but little in the topsoil. The timely, gentle rains that occur later in the year vary greatly. May and June are normally the rainiest months; July and August frequently have some degree of dryness. Well-developed corn requires about an inch of rainfall per week. The probability of an inch of rainfall per week during June is about two in five and decreases to about one in four during most of July and August. The importance of adequate subsoil moisture early in spring is obvious, because rainfall during the growing season is normally insufficient.

Maximum temperatures tend to vary little over the county, but on clear, calm nights there is a range of as much as 10 degrees or more in minimum temperatures of the cool, rural lowlands and the warmer city or uplands. Optimum crop growth is normally limited by tempera-

tures of 90° F. or higher. This temperature occurs 20 to 30 days a year in Guthrie County.

Literature Cited

(1) American Association of State Highway Officials.
1970. standard specifications for highway materials and methods of sampling and testing. Ed. 10. 2 v., illus.

(2) Bain, H. F.
1896. geology of guthrie county. Iowa Geol. Surv. Ann. Rpt. 7: 413–487, illus.

(3) Daniels, R. B. and Jordon, R. H.
1966. physiographic history and the soils, entrenched stream systems, and gullies, harrison county, iowa. U.S. Dept. Agr. Tech. Bul. 1348, 116 pp., illus.

(4) Davidson, D. T. and Associates.
1960. geologic and engineering properties of pleistocene materials in iowa. Iowa Eng. Expt. Sta. Bul. 191 and Iowa Hwy. Res. Bd. Bul. 20, (joint pub.). 250 pp., illus.

(5) Davidson, Robert R.
1961. comparison of the iowa forest resources in 1832 and 1954. Iowa St. Jour. Sci. 36: 133–136.

(6) Dideriksen, R. I.
1967. a look at iowa's soils. Jour. of Soil and Water Cons. 22: 112–114, illus.

(7) Godfrey, C. L. and Riecken, F. F.
1957. solubility of phosphorus in some genetically related loess-derived soils. Soil Sci. Soc. Amer. Proc. 21: 232–235.

(8) Hutton, C. E.
1947. studies of loess-derived soils in southwestern iowa. Soil Sci. Soc. Amer. Proc. 12: 424–431, illus.

(9) ———
1951. studies of the chemical and physical characteristics of a chrono-litho-sequence of loess-derived prairie soils of southwestern iowa. Soil Sci. Soc. Amer. Proc. 15: 318–324, illus.

(10) Iowa Department of Agriculture.
1966. iowa annual farm census. Div. of Agr. Statistics Bul. 92–AB.

(11) Kay, George F.
1916. gumbotil: a new term in pleistocene geology. Sci. 44: 637–638.

(12) ——— and Apfel, E. T.
1929. the pre-illinoian pleistocene geology of iowa. Iowa Geol. Surv. Ann. Rpt. 34: 1–304, illus.

(13) ——— and Graham, Jack B.
1943. the illinoian and post-illinoian pleistocene geology of iowa. Iowa Geol. Surv. Ann. Rpt. 38: 1–262, illus.

(14) McComb, A. L. and Loomis, W. E.
1944. subclimax prairie. Torrey Bot. Club Bul. 71: 46–76.

(15) ——— and Riecken, F. F.
1961. effect of vegetation on soils in the forest-prairie region. Rec. Adv. in Bot., Univ. of Toronto Press, 1627–1631.

(16) Ruhe, R. V.
1954. relations of the properties of wisconsin loess to topography in western iowa. Amer. Jour. Sci. 252: 663–672, illus.

(17) ———
1956. geomorphic surfaces and the nature of soils. Soil Sci. 82: 441–445, illus.

(18) ———
1959. stone lines in soils. Soil Sci. 87: 223–231.

(19) ———
1965. quaternary paleopedology. Quaternary of the U.S., INQUA Rev. Vol., Princeton Univ. Press, 766–764.

(20) ———
1968. identification of paleosols in loess deposits in the united states. Proc. VII Cong. of Int. Assoc. for Quaternary Res., 12: 49–65.

(21) ———
1969. quaternary landscapes in iowa. Iowa State Univ. Press, 255 pp., illus.

(22) ——— and Scholtes, W. H.
1955. radiocarbon dates in central iowa. Jour. Geol. 63: 82–92.

(23) ———
1956. ages and development of soil landscapes in relation to climatic and vegetational changes in iowa. Soil. Sci. Soc. Amer. Proc. 20: 264–273, illus.

(24) ———
1959. important elements in the wisconsin glacial stage: a discussion. Jour. Geol. 67: 585–593.

(25) ——— Daniels, R. B., and Cady, J. G.
1967. landscape evolution and soil formation in southwestern iowa. U.S. Dept. Agr. Tech. Bul. 1349, 242 pp., illus.

(26) Runge, E. C. A. and Riecken, F. F.
1966. influence of natural drainage on the distribution and forms of phosphorus in some iowa prairie soils. Soil Sci. Soc. Amer. Proc., v. 30, 5: 624–630.

(27) Schnur, Luther G.
1937. yield, stand, and volume tables for even-aged upland oak forests. U.S. Dept. Agr. Tech. Bul. 560, 80 pp., illus.

(28) Simonson, Roy W.
1959. outline of a generalized theory of soil genesis. Soil Sci. Soc. Amer. Proc., v. 23, 2: 152–256.

(29) ———
1962. soil classification in the united states. Sci. 137: 1027–1034.

(30) ——— Riecken, F. G., and Smith, Guy D.
1952. understanding iowa soils. 142 pp., illus.

(31) Smith, Guy D., Allaway, W. H., and Riecken, F. F.
1950. prairie soils of the upper mississippi valley. Adv. in Agron. 2: 157–205, illus.

(32) Ulrich, R.
1950. some physical changes accompanying prairie, wiesenboden, and planosol soil profile development of peorian loess in southwestern iowa. Soil Sci. Soc. Amer. Proc. 14: 287–295.

(33) ———
1951. some chemical changes accompanying profile formation of the nearly level soils developed from peorian loess in southwestern iowa. Soil Sci. Soc. Amer. Proc. 15: 324–329.

(34) United States Department of Agriculture.
1951. soil survey manual. Agr. Handb. 18, 503 pp., illus.

(35) ———
1960. soil classification, a comprehensive system, 7th approximation. 265 pp., illus. (Supplement issued in March 1967 and Sept. 1968)

(36) ———
1966. soil laboratory data and descriptions for some soils of iowa. SCS and Iowa Agr. Expt. Sta. Rpt. No. 3, 181 pp.

(37) United States Department of Defense.
1968. unified soil classification system for roads, airfields, embankments and foundations. MIL–STD–619B, 30 pp., illus.

(38) Walker, P. H.
1966. postglacial environments in relation to landscape and soils on the cary drift, iowa. Res. Bul. 549, Iowa State Univ., Ames. pp. 838–875, illus.

(39) White, Everett M.
1953. subsoil texture variations on the clarion-webster experimental farm as related to the mankato glacial deposit. Iowa Acad. Sci. 60: 438–441.

(40) ——— and Riecken, F. F.
1955. brunizem-gray brown podzolic soil biosequences. Soil Sci. Soc. Amer. Proc. 19: 504–509, illus.

Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Alluvium, local. Soil material that has been moved a short distance and deposited at the base of slopes and along small drainageways. It includes the poorly sorted material near the base of slopes that has been moved by gravity, frost action, soil creep, and local wash.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bench position. A high, shelf-like position.

Bottoms, first. The normal flood plain of a stream; land along the stream subject to overflow.

Bottoms, second. An old alluvial plain, generally flat or smooth, that borders a stream but is seldom flooded.

Calcareous. A soil that contains enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) when treated with cold dilute hydrochloric acid. (Synonym, limy).

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are:

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gently pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Contour tillage. Cultivation that follows the contour of the land, generally almost at right angles to the slope.

Drainage, soil. This term refers to the natural drainage condition of a soil before the drainage was changed through the use of artificial methods of removing excess moisture. It is evaluated by observing soil colors and by the experience of soil scientists. The terms used to express the various degrees of natural drainage are: excessively drained, somewhat excessively drained, well drained, moderately well drained, imperfectly drained, poorly drained, and very poorly drained.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Glacial drift. Rock material transported by glacial ice and then deposited; includes the assorted and unassorted materials deposited by streams flowing from glaciers.

Glacial outwash. Cross-bedded gravel, sand, and silt deposited by melt water as it flowed from glacial ice. Referred to in this report as "outwash areas" or "outwashes."

Glacial till. Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gley. A soil horizon in which waterlogging and lack of oxygen have caused the material to be a neutral gray in color. The term "gleyed" is applied, as in "moderately gleyed soil," to soil horizons that have yellow and gray mottling caused by intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major soil horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and which therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A horizon to the underlying C horizon. The B horizon also has distinctive characteristics caused by (1) accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. The combined A and B horizon is usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Interfluve. The land between two adjacent streams flowing in the same general direction.

Leaching, soil. The removal of materials in solution by the passage of water through the soil.

Loess. A deposit of silty material that has been transported by wind. It is usually uniform unstratified silt, but may contain some fine sand and clay.

Mottles. Streaks or spots of color in soil caused by accumulations of lime, organic matter, colloids, iron compounds, or by some soil-forming process. Generally, gray or brown mottles indicate impeded drainage, but mottles of other colors may not be related to drainage. Mottles are described by noting contrast, abundance, and size. Contrast is described by the terms *faint*, *distinct*, and *prominent*; abundance by *few*, *common*, and *many*; size by *fine*, *medium*, and *coarse*.

Paleosol. An antiquated soil that was formed during the geologic past and was buried and preserved by more recent sedimentation. This kind of buried soil is often reexposed on the modern surface by subsequent erosion. It then occurs within the continuum of soils on the modern surface and is called an exhumed paleosol.

Parent material. The weathered rock or partly weathered soil material from which soil has formed. The C horizon of a soil profile.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Percolation. The downward movement of water through the soil.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour" soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. As a soil separate, individual rock or mineral fragments ranging from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but they may be any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil separates. Mineral particles, less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: Very coarse sand (2.0 to 1.0 millimeter); coarse sand (1.0 to 0.5 millimeter); medium sand (0.5 to 0.25 millimeter); fine sand (0.25 to 0.10 millimeter); very fine sand (0.10 to 0.05 millimeter); silt (0.05 to 0.002 millimeter); and clay (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

Solum, soil. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum, or true soil; the C horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a stream; frequently called second bottom, as contrasted with flood plain, and seldom subject to flooding.

Terrace (structural). An embankment or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so that they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Upland. Land above the lowlands along rivers or between hills.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper or perched water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. Other information is given in tables as follows:

Acreage and extent, table 1, page 11.
Predicted yields, table 2, page 73.

Use of the soils for engineering, tables 3, 4, 5, page 80 through page 103.

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Number	Page
192D2	Adair clay loam, 9 to 14 percent slopes, moderately eroded	13	IVe-1	69	7	77
192E2	Adair clay loam, 14 to 18 percent slopes, moderately eroded	13	VIe-1	70	7	77
192E3	Adair soils, 14 to 18 percent slopes, severely eroded	13	VIIe-1	71	7	77
315	Alluvial land	13	Vw-1	70	9	77
733	Calco silty clay loam	15	IIw-2	66	9	77
507	Canisteo silty clay loam	16	IIw-1	66	9	77
318F	Clanton silt loam, 18 to 30 percent slopes	17	VIIe-1	71	7	77
222C2	Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	17	IVw-1	70	7	77
222D2	Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	18	IVe-1	69	7	77
138B	Clarion loam, 2 to 5 percent slopes	18	IIe-2	65	3	75
138B2	Clarion loam, 2 to 5 percent slopes, moderately eroded	19	IIe-2	65	3	75
138C	Clarion loam, 5 to 9 percent slopes	19	IIIe-3	67	3	75
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	19	IIIe-3	67	3	75
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	19	IIIe-4	68	3	75
138E	Clarion loam, 14 to 18 percent slopes	19	IVe-2	69	3	75
69D2	Clearfield silty clay loam, 9 to 14 percent slopes, moderately eroded	20	IVe-1	69	9	77
80B	Clinton silt loam, 2 to 5 percent slopes	21	IIe-1	65	2	75
80C2	Clinton silt loam, 5 to 9 percent slopes, moderately eroded	21	IIIe-1	67	2	75
80D2	Clinton silt loam, 9 to 14 percent slopes, moderately eroded	21	IIIe-2	67	2	75
80D3	Clinton soils, 9 to 14 percent slopes, severely eroded	22	IVe-2	69	2	75
133A	Color silty clay loam, 0 to 2 percent slopes	22	IIw-2	66	9	77
133B	Colo silty clay loam, 2 to 5 percent slopes	23	IIw-3	66	9	77
C133A	Colo silt loam, channeled, 0 to 2 percent slopes	23	Vw-1	70	9	77
133A+	Colo silt loam, overwash, 0 to 2 percent slopes	23	IIw-2	66	9	77
133B+	Colo silt loam, overwash, 2 to 5 percent slopes	23	IIw-3	66	9	77
11B	Colo-Judson complex, 2 to 5 percent slopes	23	IIw-3	66	9	77
585B	Colo-Spillville complex, 2 to 5 percent slopes	23	IIw-3	66	9	77
615B	Colo-Spillville complex, channeled, 2 to 5 percent slopes	24	Vw-1	70	9	77
203	Cylinder loam	25	I-2	64	6	76
675C2	Dickinson-Sharpsburg complex, 5 to 9 percent slopes, moderately eroded	25	IIIe-3	67	1	75
675D2	Dickinson-Sharpsburg complex, 9 to 14 percent slopes, moderately eroded	25	IIIe-4	68	1	75
428B	Ely silty clay loam, 2 to 5 percent slopes	26	IIe-3	65	6	76
179D2	Gara loam, 9 to 14 percent slopes, moderately eroded	27	IVe-1	69	3	75
179E2	Gara loam, 14 to 18 percent slopes, moderately eroded	28	VIe-2	71	3	75
179F2	Gara loam, 18 to 25 percent slopes, moderately eroded	28	VIIe-1	71	4 or 5	76
179G2	Gara loam, 25 to 40 percent slopes, moderately eroded	28	VIIe-1	71	4 or 5	76
993E2	Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded	28	VIe-1	70	3	75
313E2	Gosport silt loam, 9 to 18 percent slopes, moderately eroded	29	VIIe-1	71	7	77
313F2	Gosport silt loam, 18 to 30 percent slopes, moderately eroded	29	VIIe-1	71	7	77

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Number	Page
95	Harps loam	30	IIw-1	66	9	77
416E	Hesch sandy loam, 9 to 18 percent slopes	31	VIIs-1	72	1	75
417D	Hesch loam, 9 to 14 percent slopes	31	VIs-1	71	1	75
417E	Hesch loam, 14 to 18 percent slopes	31	VIIs-1	72	1	75
269	Humeston silt loam	32	IIIw-1	69	9	77
8B	Judson silty clay loam, 2 to 5 percent slopes	33	IIe-3	65	2	75
8C	Judson silty clay loam, 5 to 9 percent slopes	33	IIIe-1	67	2	75
212	Kennebec silt loam	34	I-3	64	8	77
76A	Ladoga silt loam, 0 to 2 percent slopes	35	I-1	64	2	75
76B	Ladoga silt loam, 2 to 5 percent slopes	35	IIe-1	65	2	75
76C	Ladoga silt loam, 5 to 9 percent slopes	35	IIIe-1	67	2	75
76C2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	35	IIIe-1	67	2	75
76D	Ladoga silt loam, 9 to 14 percent slopes	36	IIIe-2	67	2	75
76D2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	36	IIIe-2	67	2	75
76E2	Ladoga silt loam, 14 to 18 percent slopes, moderately eroded	36	IVe-2	69	2	75
T76B	Ladoga silt loam, benches, 2 to 5 percent slopes	36	IIe-1	65	2	75
822D2	Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	37	IVe-1	69	7	77
822E2	Lamoni silty clay loam, 14 to 18 percent slopes, moderately eroded	37	VIe-1	70	7	77
236B	Lester loam, 2 to 5 percent slopes	38	IIe-2	65	3	75
236C2	Lester loam, 5 to 9 percent slopes, moderately eroded	38	IIIe-3	67	3	75
236D2	Lester loam, 9 to 14 percent slopes, moderately eroded	38	IIIe-4	68	3	75
65E2	Lindley loam, 14 to 18 percent slopes, moderately eroded	39	VIe-2	71	3	75
65F2	Lindley loam, 18 to 25 percent slopes, moderately eroded	39	VIIe-1	71	4 or 5	76
65G2	Lindley loam, 25 to 40 percent slopes, moderately eroded	40	VIIe-1	71	4 or 5	76
65F3	Lindley soils, 18 to 25 percent slopes, severely eroded	40	VIIe-1	71	4 or 5	76
368	Macksburg silty clay loam	41	I-1	64	6	76
354	Marsh	41	VIIw-1	71	9	77
9B	Marshall silty clay loam, 2 to 5 percent slopes	42	IIe-1	65	2	75
9C2	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	42	IIIe-1	67	2	75
9D2	Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	42	IIIe-2	67	2	75
T9B	Marshall silty clay loam, benches, 2 to 5 percent slopes	42	IIe-1	65	2	75
415D	Montieth loamy sand, 9 to 14 percent slopes	43	VIs-1	71	1	75
415E	Montieth loamy sand, 14 to 18 percent slopes	43	VIIs-1	72	1	75
415F	Montieth loamy sand, 18 to 30 percent slopes	43	VIIs-1	72	1	75
88	Nevin silty clay loam	45	I-1	64	6	76
55A	Nicollet loam, 1 to 3 percent slopes	46	I-1	64	6	76
220	Nodaway silt loam	47	I-3	64	8	77
C220	Nodaway silt loam, channeled	47	Vw-1	70	8	77
6	Okoboji silty clay loam	48	IIIw-1	69	9	77
273B	Olmitz loam, 2 to 5 percent slopes	49	IIe-3	65	3	75
273C	Olmitz loam, 5 to 9 percent slopes	49	IIIe-3	67	3	75
201B	Olmitz-Colo complex, channeled, 2 to 7 percent slopes	49	Vw-1	70	3	75
73D2	Salida sandy loam, 7 to 14 percent slopes, moderately eroded	50	VIs-1	71	1	75
370A	Sharpsburg silty clay loam, 0 to 2 percent slopes	51	I-1	64	2	75

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Number	Page
370B	Sharpsburg silty clay loam, 2 to 5 percent slopes-------	51	IIe-1	65	2	75
370C	Sharpsburg silty clay loam, 5 to 9 percent slopes-------	51	IIIe-1	67	2	75
370C2	Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded-------------------------------------	51	IIIe-1	67	2	75
370D	Sharpsburg silty clay loam, 9 to 14 percent slopes------	52	IIIe-2	67	2	75
370D2	Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded-------------------------------------	52	IIIe-2	67	2	75
370E2	Sharpsburg silty clay loam, 14 to 18 percent slopes, moderately eroded-------------------------------------	52	IVe-2	69	2	75
T370B	Sharpsburg silty clay loam, benches, 2 to 5 percent slopes--	52	IIe-1	65	2	75
24B	Shelby loam, 2 to 5 percent slopes----------------------	54	IIe-2	65	3	75
24C2	Shelby loam, 5 to 9 percent slopes, moderately eroded---	54	IIIe-3	67	3	75
24D2	Shelby loam, 9 to 14 percent slopes, moderately eroded--	54	IIIe-4	68	3	75
24E2	Shelby loam, 14 to 18 percent slopes, moderately eroded--	54	IVe-2	69	3	75
24F2	Shelby loam, 18 to 25 percent slopes, moderately eroded--	54	VIe-2	71	4 or 5	76
24E3	Shelby soils, 14 to 18 percent slopes, severely eroded--	54	VIe-2	71	3	75
24F3	Shelby soils, 18 to 25 percent slopes, severely eroded--	55	VIe-2	71	4 or 5	76
93D2	Shelby-Adair complex, 9 to 14 percent slopes, moderately eroded-------------------------------------	55	IVe-1	69	3	75
93D3	Shelby-Adair complex, 9 to 14 percent slopes, severely eroded---------------------------------------	55	VIe-1	70	3	75
93E2	Shelby-Adair complex, 14 to 18 percent slopes, moderately eroded-------------------------------------	55	VIe-1	70	3	75
93E3	Shelby-Adair complex, 14 to 18 percent slopes, severely eroded---------------------------------------	55	VIIe-1	71	3	75
485A	Spillville loam, 1 to 3 percent slopes------------------	56	I-3	64	8	77
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded--	57	IIIe-3	67	3	75
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded--	57	IIIe-4	68	3	75
62E2	Storden loam, 14 to 18 percent slopes, moderately eroded--	57	IVe-2	69	3	75
62F2	Storden loam, 18 to 25 percent slopes, moderately eroded--	58	VIe-2	71	4 or 5	76
51A	Vesser silt loam, 0 to 2 percent slopes-----------------	58	IIw-2	66	9	77
51A+	Vesser silt loam, overwash, 0 to 2 percent slopes-------	59	IIw-2	66	9	77
308A	Wadena loam, deep, 0 to 2 percent slopes----------------	59	I-2	64	1	75
308B	Wadena loam, deep, 2 to 5 percent slopes----------------	60	IIe-2	65	1	75
308C	Wadena loam, deep, 5 to 14 percent slopes---------------	60	IIIe-3	67	1	75
108A	Wadena loam, moderately deep, 0 to 2 percent slopes-----	60	IIs-1	66	1	75
108B	Wadena loam, moderately deep, 2 to 5 percent slopes-----	60	IIe-2	65	1	75
108C2	Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded-------------------------------------	60	IIIe-3	67	1	75
107	Webster silty clay loam---------------------------------	61	IIw-1	66	9	77
54+	Zook silt loam, overwash--------------------------------	62	IIw-2	66	9	77
54	Zook silty clay loam------------------------------------	62	IIw-2	66	9	77

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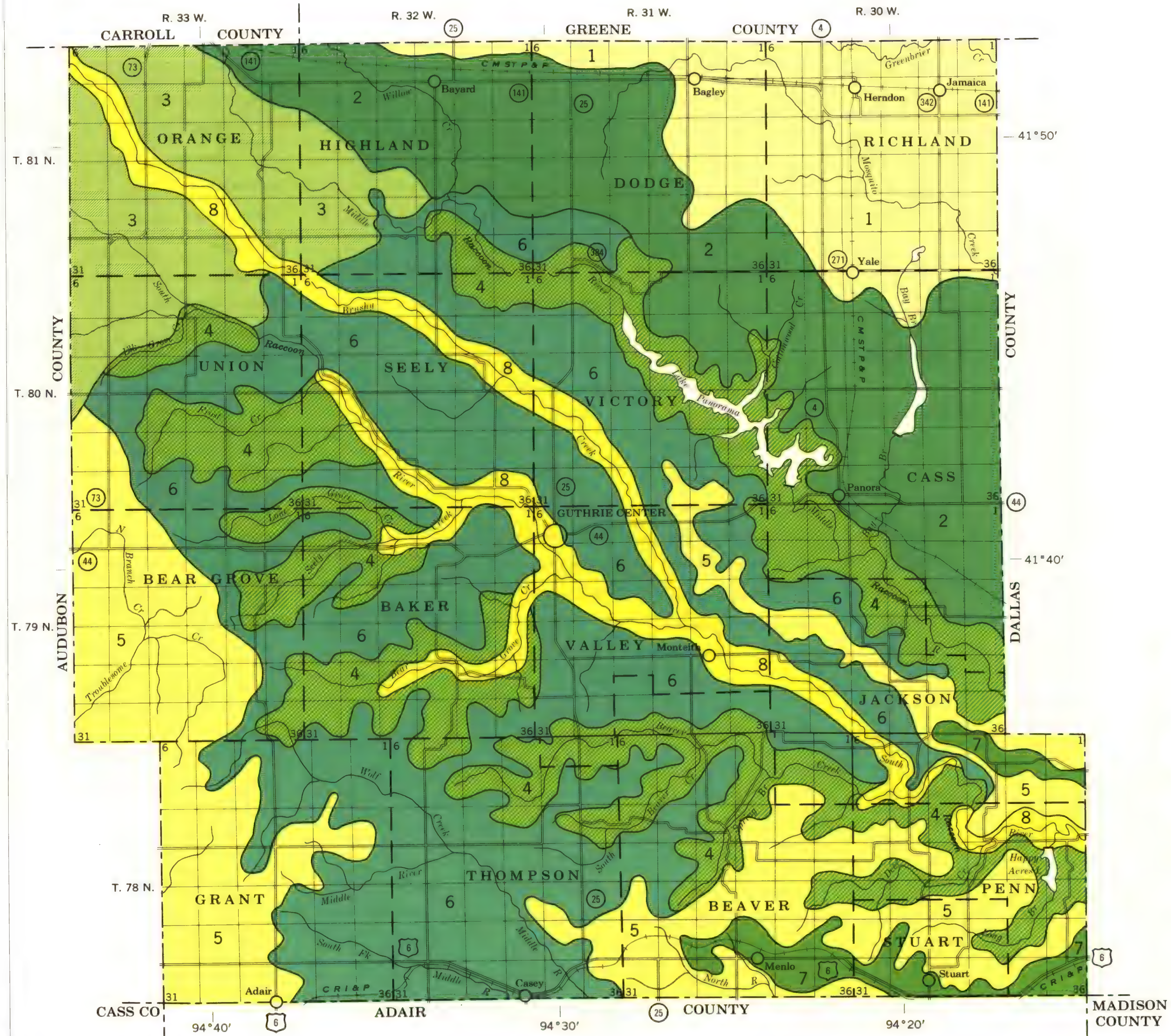


Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION

GENERAL SOIL MAP

GUTHRIE COUNTY, IOWA

Scale 1 : 190,080

1 0 1 2 3 4 Miles

N

SOIL ASSOCIATIONS*

1 Webster-Nicollet association: Nearly level, loamy, poorly drained and somewhat poorly drained soils on uplands

2 Clarion association: Gently sloping to strongly sloping, loamy, well-drained soils on uplands

3 Marshall-Shelby association: Gently sloping to strongly sloping, silty and loamy, well drained and moderately well drained soils on uplands

4 Gara-Lindley association: Strongly sloping to very steep, loamy, moderately well drained soils on uplands

5 Sharpsburg association: Gently sloping and moderately sloping, silty, moderately well drained soils on uplands

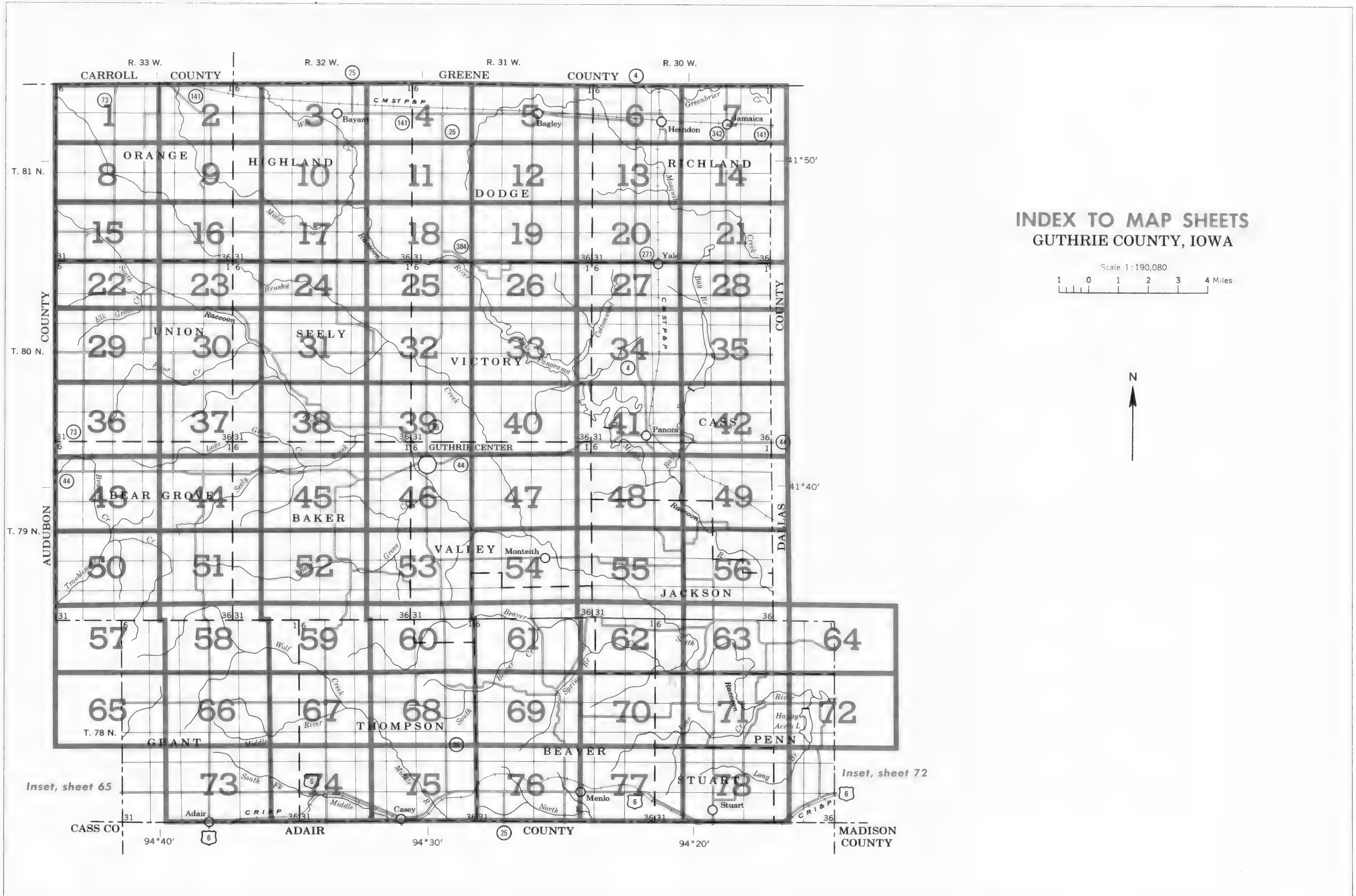
6 Sharpsburg-Ladoga-Shelby association: Gently sloping to moderately steep, silty and loamy, moderately well drained soils on uplands

7 Sharpsburg-Macksburg association: Nearly level to gently sloping, silty, moderately well drained and somewhat poorly drained soils on uplands

8 Zook-Colo-Vesser association: Nearly level, silty, poorly drained soils on bottom lands

*The texture given in the descriptive heading refers to the surface layer of the major soils in the association.

Compiled 1972



INDEX TO MAP SHEETS
GUTHRIE COUNTY, IOWA
Scale 1:190,080
1 0 1 2 3 4 Miles
N
CARROLL COUNTY
GREENE COUNTY
AUDUBON COUNTY
DALLAS COUNTY
CASS CO
ADAIR COUNTY
MADISON COUNTY
R. 33 W.
R. 32 W.
R. 31 W.
R. 30 W.
T. 81 N.
T. 80 N.
T. 79 N.
T. 78 N.
ORANGE
HIGHLAND
DODGE
RICHLAND
UNION
SEELY
VICTORY
CASS
BEAR GROVE
BAKER
VALLEY
JACKSON
GRANT
THOMPSON
BEAVER
PENN
STUART
Bayard
Bagley
Herndon
Jamaica
Yale
Panora
GUTHRIE CENTER
Monteith
Adair
Casey
Menlo
Stuart
Inset, sheet 65
Inset, sheet 72
94°40′
94°30′
94°20′
41°50′
41°40′

SOIL LEGEND

Symbols consist of numbers or a combination of numbers and letters, for example, 54 and 93D3. The number designates the kind of soil or land type. A capital letter, A, B, C, D, E, F, or G, following a number indicates the slope. Symbols without a slope letter are those of nearly level soils. A final number, 2 or 3, in a symbol indicates that the soil is moderately eroded or severely eroded. A "+" at the end of the symbol indicates an overwashed soil.

SYMBOL	NAME
6	Okoboji silty clay loam
8B	Judson silty clay loam, 2 to 5 percent slopes
8C	Judson silty clay loam, 5 to 9 percent slopes
9B	Marshall silty clay loam, 2 to 5 percent slopes
9C2	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded
9D2	Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded
T9B	Marshall silty clay loam, benches, 2 to 5 percent slopes
11B	Colo-Judson complex, 2 to 5 percent slopes
24B	Shelby loam, 2 to 5 percent slopes
24C2	Shelby loam, 5 to 9 percent slopes, moderately eroded
24D2	Shelby loam, 9 to 14 percent slopes, moderately eroded
24E2	Shelby loam, 14 to 18 percent slopes, moderately eroded
24F2	Shelby loam, 18 to 25 percent slopes, moderately eroded
24E3	Shelby soils, 14 to 18 percent slopes, severely eroded
24F3	Shelby soils, 18 to 25 percent slopes, severely eroded
51A	Vesser silt loam, 0 to 2 percent slopes
51A+	Vesser silt loam, overwash, 0 to 2 percent slopes
54	Zook silty clay loam
54+	Zook silt loam, overwash
55A	Nicollet loam, 1 to 3 percent slopes
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded
62E2	Storden loam, 14 to 18 percent slopes, moderately eroded
62F2	Storden loam, 18 to 25 percent slopes, moderately eroded
65E2	Lindley loam, 14 to 18 percent slopes, moderately eroded
65F2	Lindley loam, 18 to 25 percent slopes, moderately eroded
65G2	Lindley loam, 25 to 40 percent slopes, moderately eroded
65F3	Lindley soils, 18 to 25 percent slopes, severely eroded
69D2	Clearfield silty clay loam, 9 to 14 percent slopes, moderately eroded
73D2	Salida sandy loam, 7 to 14 percent slopes, moderately eroded
76A	Ladoga silt loam, 0 to 2 percent slopes
76B	Ladoga silt loam, 2 to 5 percent slopes
76C	Ladoga silt loam, 5 to 9 percent slopes
76C2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded
76D	Ladoga silt loam, 9 to 14 percent slopes
76D2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded
76E2	Ladoga silt loam, 14 to 18 percent slopes, moderately eroded
T76B	Ladoga silt loam, benches, 2 to 5 percent slopes
80B	Clinton silt loam, 2 to 5 percent slopes
80C2	Clinton silt loam, 5 to 9 percent slopes, moderately eroded
80D2	Clinton silt loam, 9 to 14 percent slopes, moderately eroded
80D3	Clinton soils, 9 to 14 percent slopes, severely eroded
88	Nevin silty clay loam
93D2	Shelby-Adair complex, 9 to 14 percent slopes, moderately eroded
93D3	Shelby-Adair complex, 9 to 14 percent slopes, severely eroded
93E2	Shelby-Adair complex, 14 to 18 percent slopes, moderately eroded
93E3	Shelby-Adair complex, 14 to 18 percent slopes, severely eroded
95	Harps loam
107	Webster silty clay loam
108A	Wadena loam, moderately deep, 0 to 2 percent slopes
108B	Wadena loam, moderately deep, 2 to 5 percent slopes
108C2	Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded
133A	Colo silty clay loam, 0 to 2 percent slopes
133B	Colo silty clay loam, 2 to 5 percent slopes
C133A	Colo silt loam, channeled, 0 to 2 percent slopes
133A+	Colo silt loam, overwash, 0 to 2 percent slopes
133B+	Colo silt loam, overwash, 2 to 5 percent slopes
138B	Clarion loam, 2 to 5 percent slopes
138B2	Clarion loam, 2 to 5 percent slopes, moderately eroded
138C	Clarion loam, 5 to 9 percent slopes
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded
138E	Clarion loam, 14 to 18 percent slopes
179D2	Gara loam, 9 to 14 percent slopes, moderately eroded
179E2	Gara loam, 14 to 18 percent slopes, moderately eroded
179F2	Gara loam, 18 to 25 percent slopes, moderately eroded
179G2	Gara loam, 25 to 40 percent slopes, moderately eroded
192D2	Adair clay loam, 9 to 14 percent slopes, moderately eroded
192E2	Adair clay loam, 14 to 18 percent slopes, moderately eroded
192E3	Adair soils, 14 to 18 percent slopes, severely eroded
201B	Olmitz-Colo complex, channeled, 2 to 7 percent slopes
203	Cylinder loam
212	Kennebec silt loam
220	Nodaway silt loam
C220	Nodaway silt loam, channeled
222C2	Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded
222D2	Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded
236B	Lester loam, 2 to 5 percent slopes
236C2	Lester loam, 5 to 9 percent slopes, moderately eroded
236D2	Lester loam, 9 to 14 percent slopes, moderately eroded
269	Humeston silt loam
273B	Olmitz loam, 2 to 5 percent slopes
273C	Olmitz loam, 5 to 9 percent slopes
308A	Wadena loam, deep, 0 to 2 percent slopes
308B	Wadena loam, deep, 2 to 5 percent slopes
308C	Wadena loam, deep, 5 to 14 percent slopes
313E2	Gosport silt loam, 9 to 18 percent slopes, moderately eroded
313F2	Gosport silt loam, 18 to 30 percent slopes, moderately eroded
315	Alluvial land
318F	Clanton silt loam, 18 to 30 percent slopes
354	Marsh
368	Macksburg silty clay loam
370A	Sharpsburg silty clay loam, 0 to 2 percent slopes
370B	Sharpsburg silty clay loam, 2 to 5 percent slopes
370C	Sharpsburg silty clay loam, 5 to 9 percent slopes
370C2	Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded
370D	Sharpsburg silty clay loam, 9 to 14 percent slopes
370D2	Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded
370E2	Sharpsburg silty clay loam, 14 to 18 percent slopes, moderately eroded
T370B	Sharpsburg silty clay loam, benches, 2 to 5 percent slopes
415D	Montieth loamy sand, 9 to 14 percent slopes
415E	Montieth loamy sand, 14 to 18 percent slopes
415F	Montieth loamy sand, 18 to 30 percent slopes
416E	Hesch sandy loam, 9 to 18 percent slopes
417D	Hesch loam, 9 to 14 percent slopes
417E	Hesch loam, 14 to 18 percent slopes
428B	Ely silty clay loam, 2 to 5 percent slopes
485A	Spillville loam, 1 to 3 percent slopes
507	Canisteo silty clay loam
585B	Colo-Spillville complex, 2 to 5 percent slopes
615B	Colo-Spillville complex, channeled, 2 to 5 percent slopes
675C2	Dickinson-Sharpsburg complex, 5 to 9 percent slopes, moderately eroded
675D2	Dickinson-Sharpsburg complex, 9 to 14 percent slopes, moderately eroded
733	Calco silty clay loam
822D2	Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded
822E2	Lamoni silty clay loam, 14 to 18 percent slopes, moderately eroded
993E2	Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded

GUTHRIE COUNTY, IOWA

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads

- Divided
- Good motor
- Poor motor
- Trail

Highway markers

- National Interstate
- U. S.
- State or county

Railroads

- Single track
- Multiple track
- Abandoned

Bridges and crossings

- Road
- Trail
- Railroad
- Ferry — FY
- Ford — FORD
- Grade
- R. R. over
- R. R. under

Buildings

- School
- Church

Mine and quarry

Gravel pit

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Windmill

Located object

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line

- Perennial
- Intermittent

Streams, single-line

- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable non-stable grade
  - Not crossable stabilized grade

Canals and ditches

Lakes and ponds

- Perennial — water, w
- Intermittent — int

Spring

Marsh or swamp

Wet spot

Drainage end or alluvial fan

RELIEF

Escarpments

- Bedrock
- Other

Short steep slope

Prominent peak

Depressions (Large, Small)

- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol — Dx
- Gravel
- Stoniness
  - Stony
  - Very stony
- Limerock outcrop
- Chert fragments
- Red clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Glacial till
- Shale spot
- Calcareous spot less than one acre
- Sandstone spot
- Muck
- Spot of fine textured till or sediment similar to Clarinda series, less than two acres

(1)

N

GUTHRIE COUNTY, IOWA NO. 1

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Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

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GUTHRIE COUNTY, IOWA NO. 2

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3

GUTHRIE COUNTY, IOWA NO. 3

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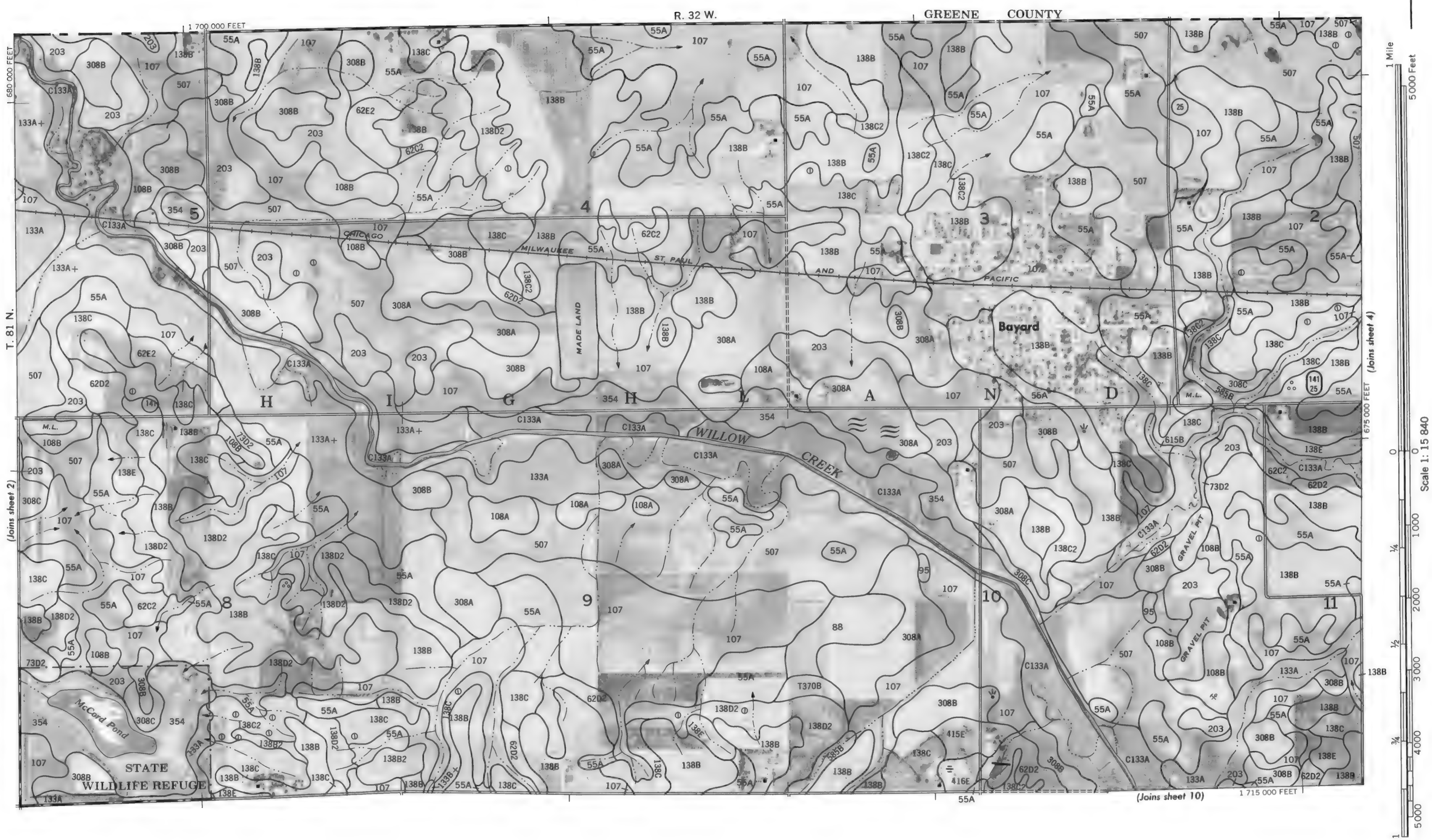

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GUTHRIE COUNTY, IOWA NO. 4

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5

N

GUTHRIE COUNTY, IOWA NO. 5

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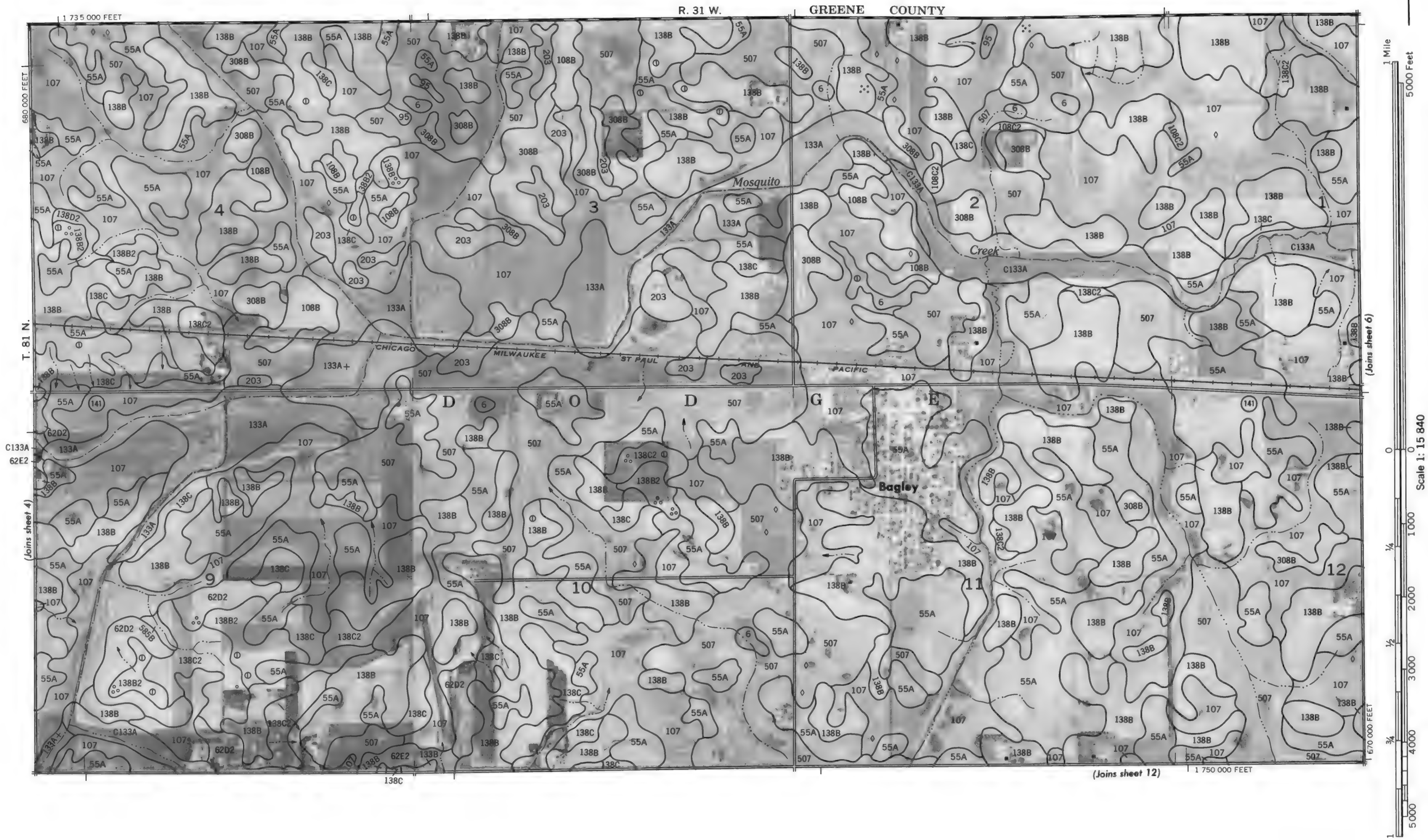

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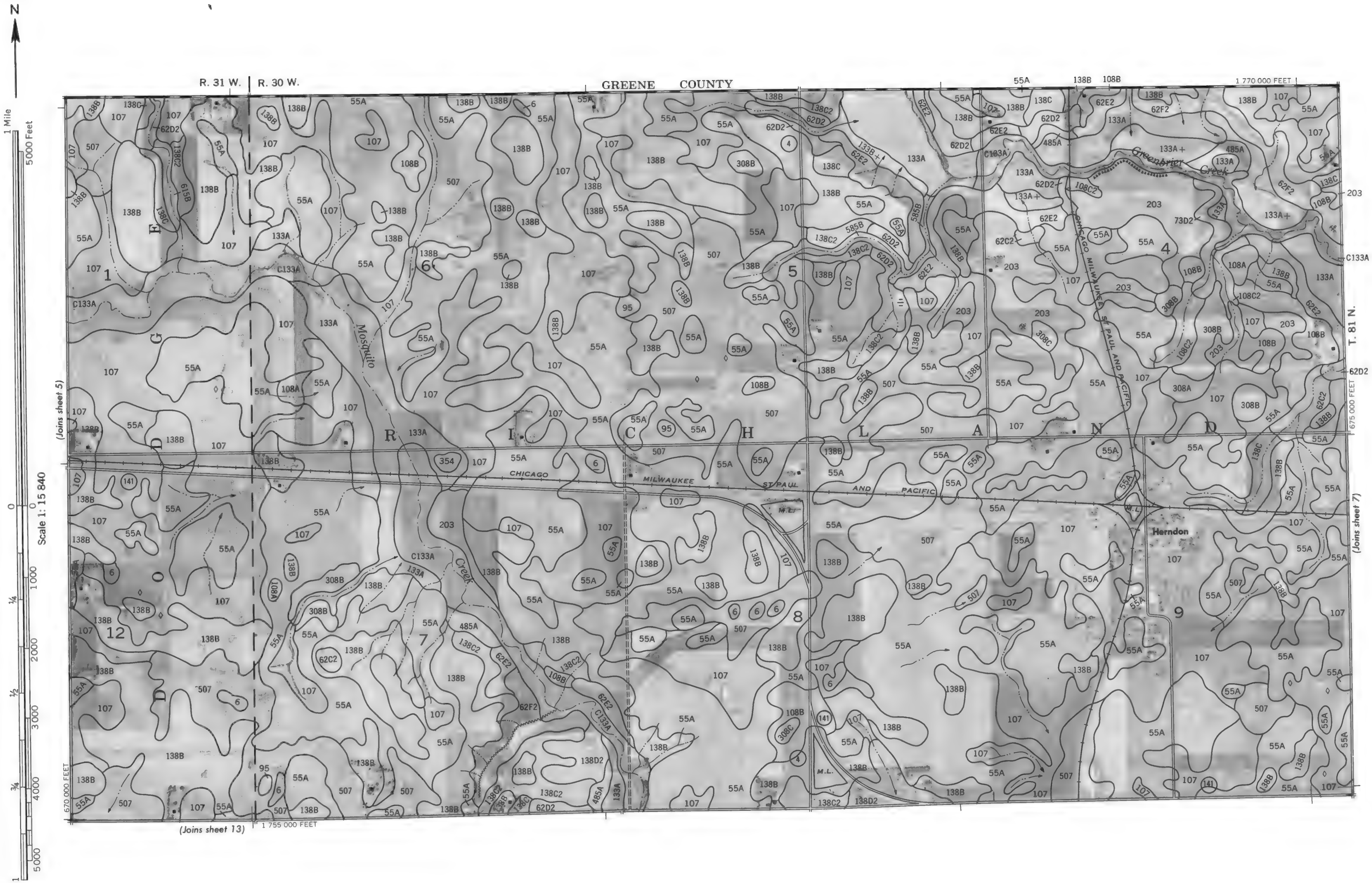
GUTHRIE COUNTY, IOWA — SHEET NUMBER 6



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GUTHRIE COUNTY, IOWA NO. 6

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7

GUTHRIE COUNTY, IOWA NO. 7

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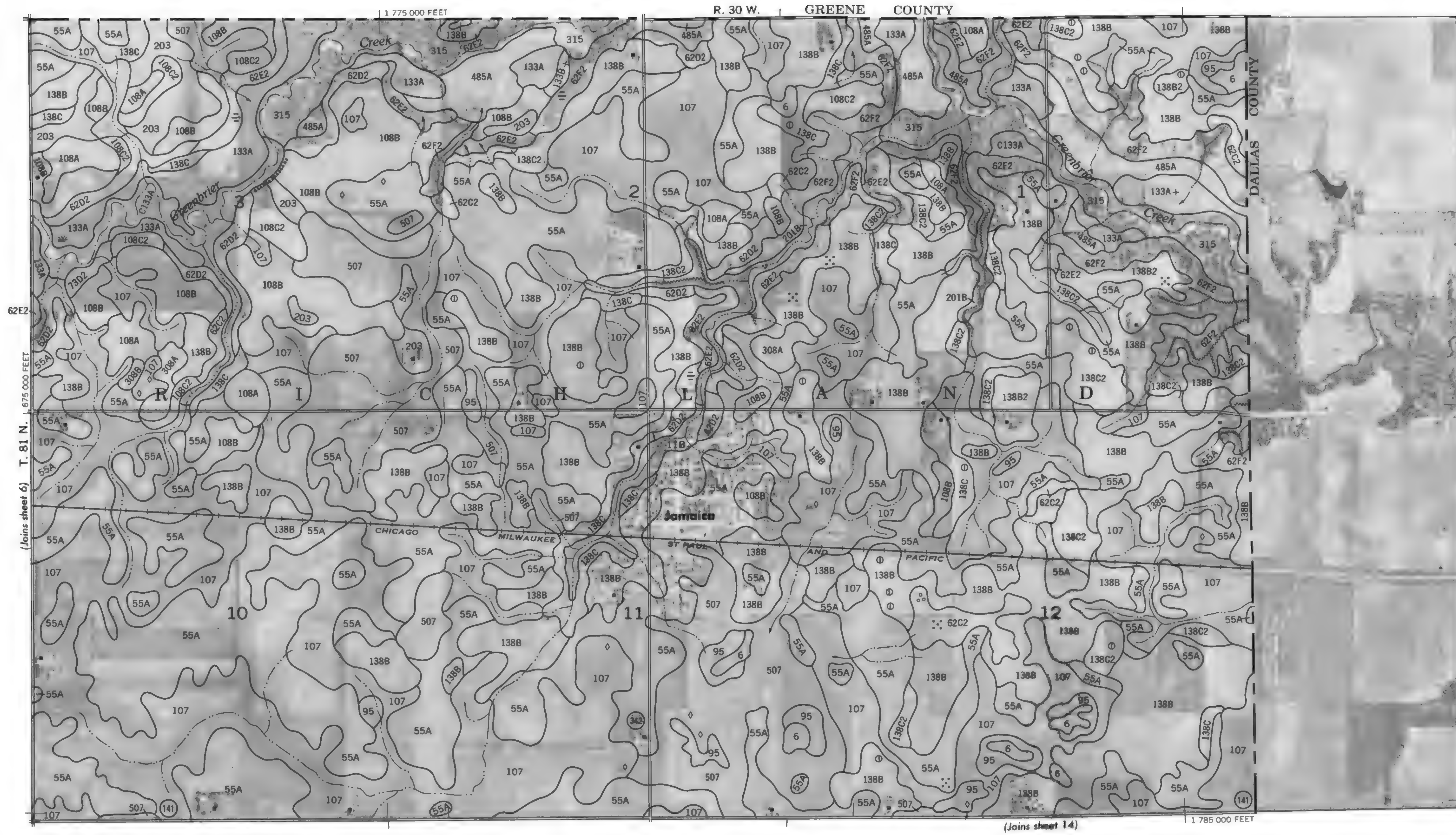
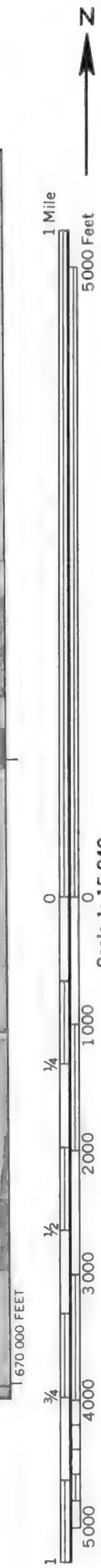
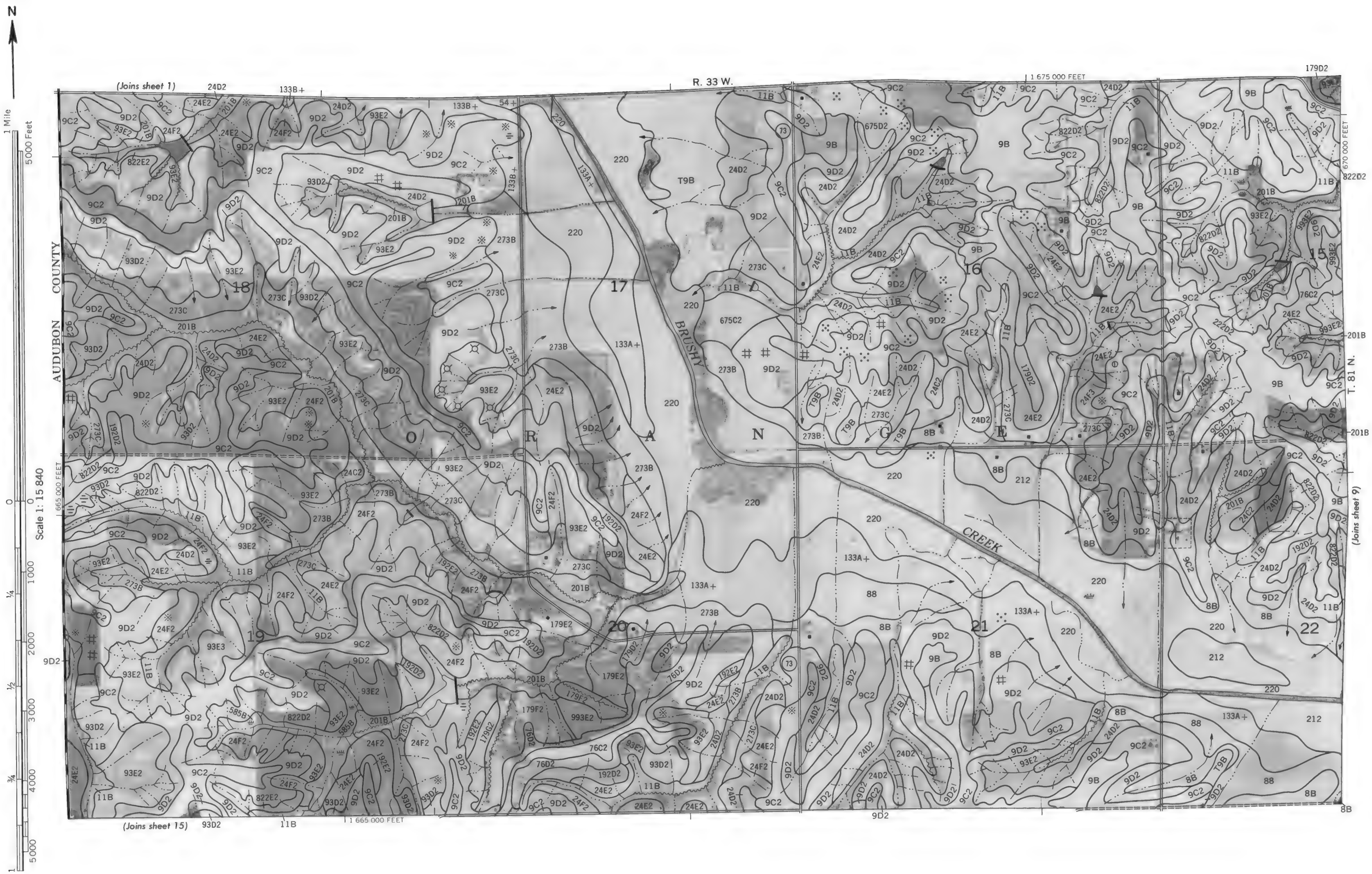




Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

8



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GUTHRIE COUNTY, IOWA NO. 9

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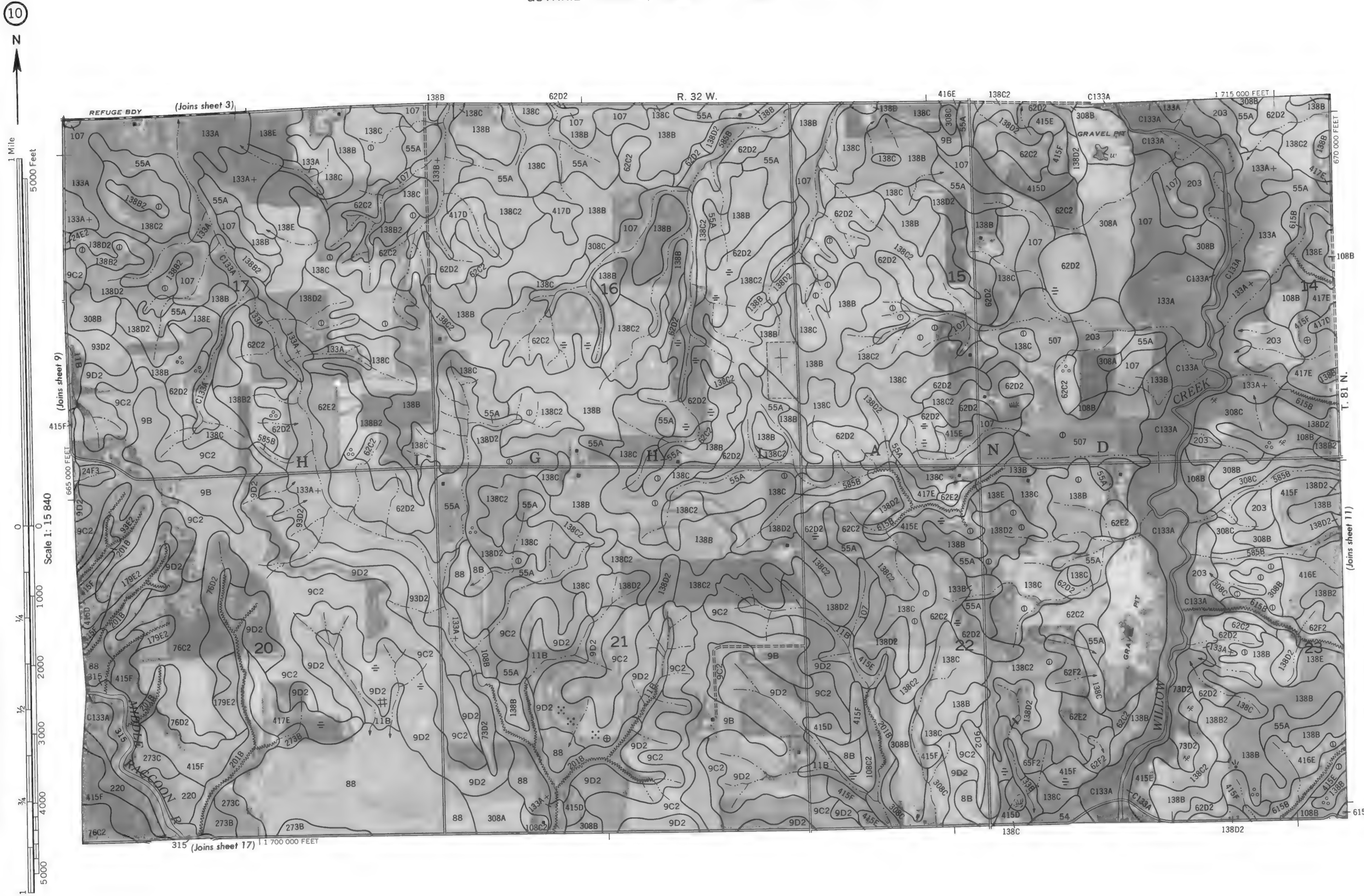

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GUTHRIE COUNTY, IOWA NO. 10

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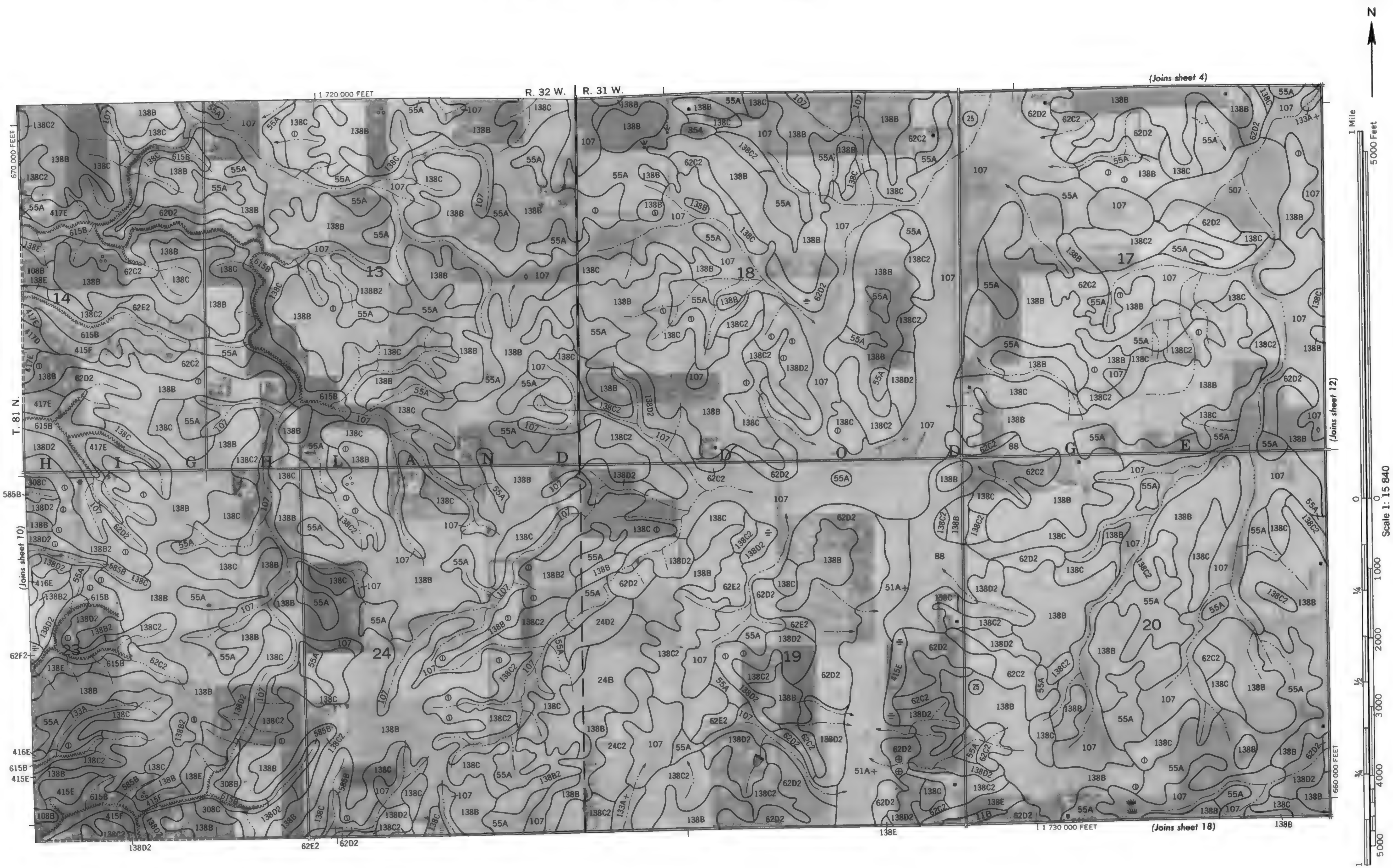

GUTHRIE COUNTY, IOWA NO. 11

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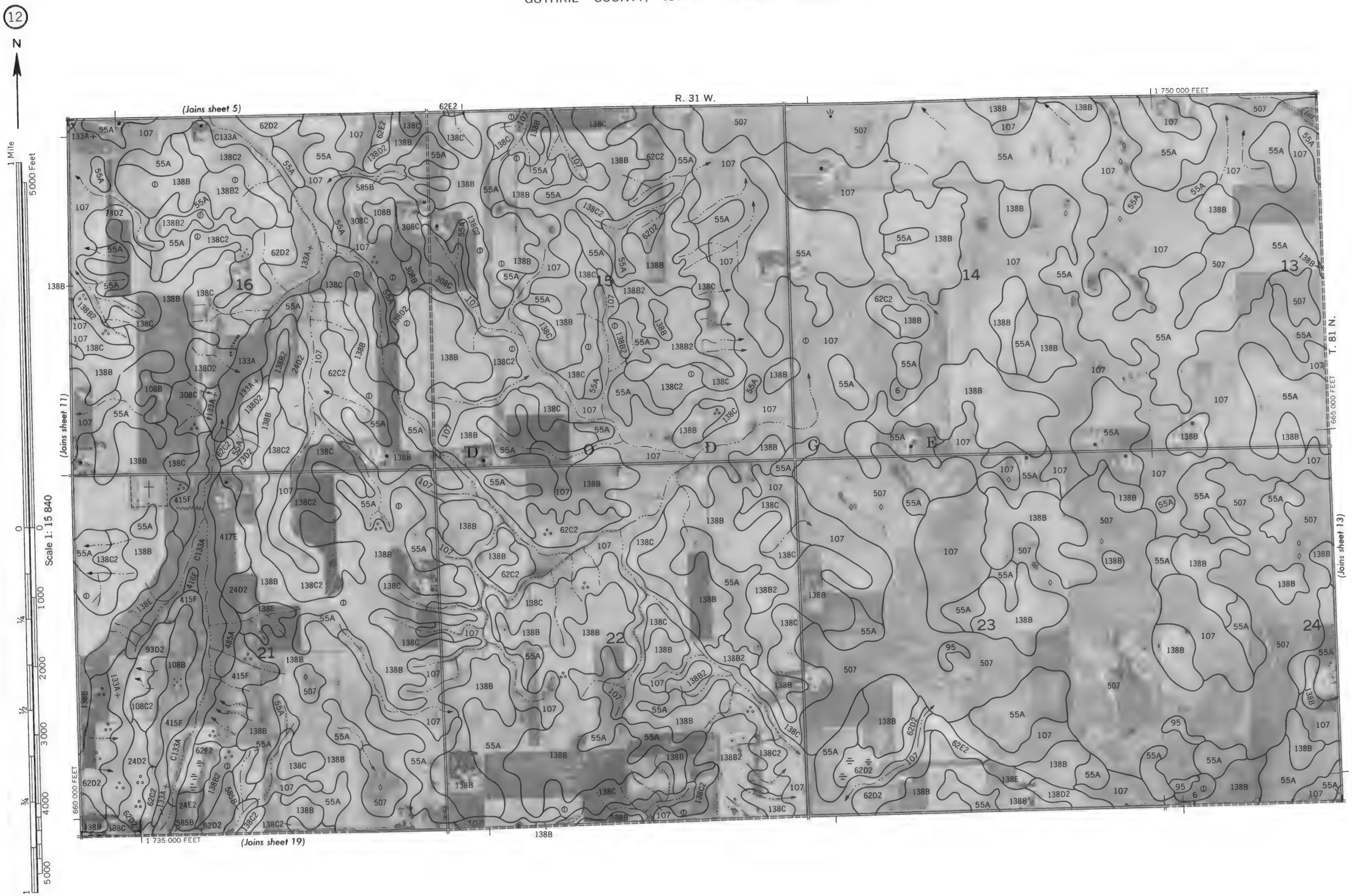

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GUTHRIE COUNTY, IOWA NO. 12

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GUTHRIE COUNTY, IOWA NO. 13

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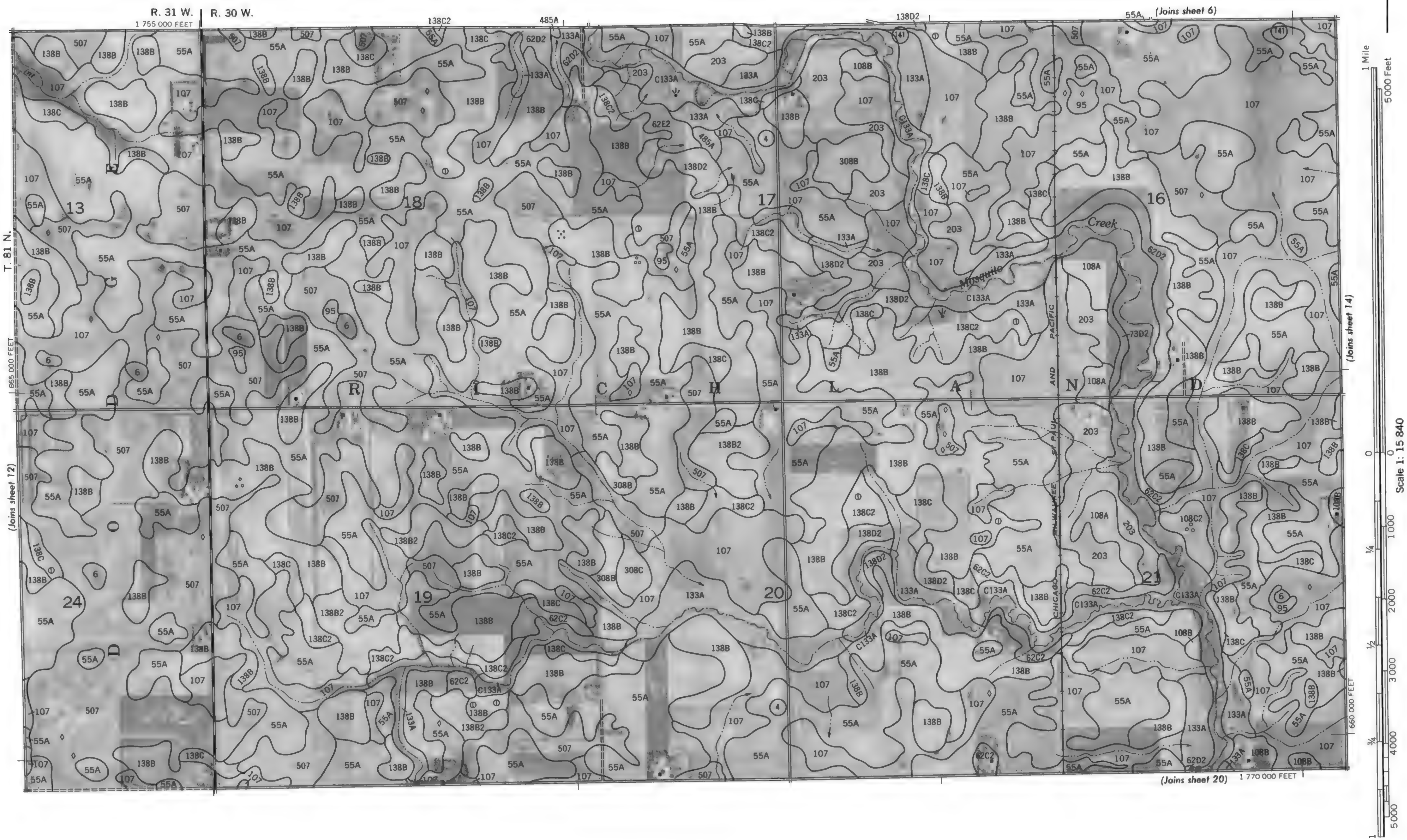

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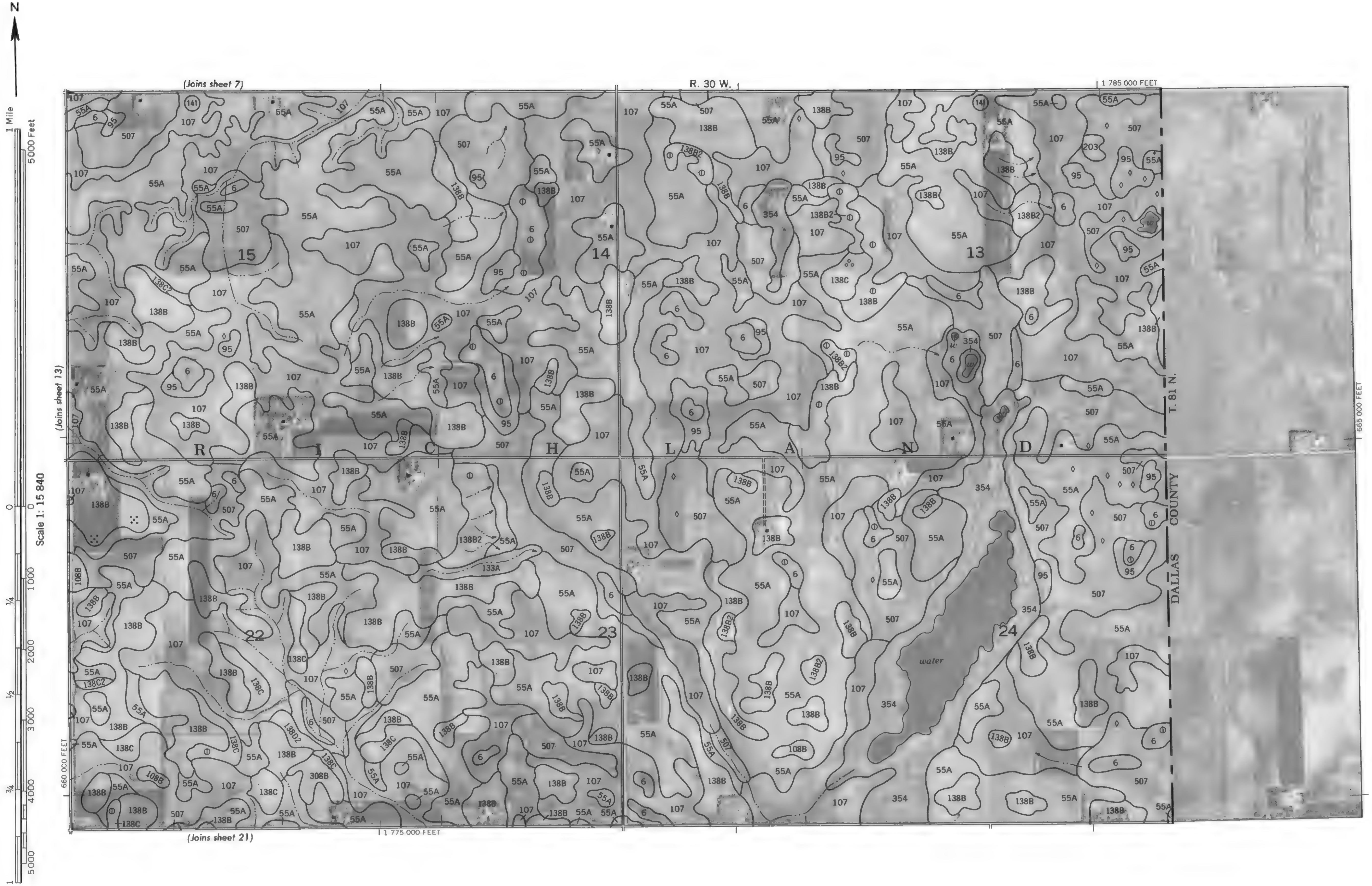
GUTHRIE COUNTY, IOWA — SHEET NUMBER 14

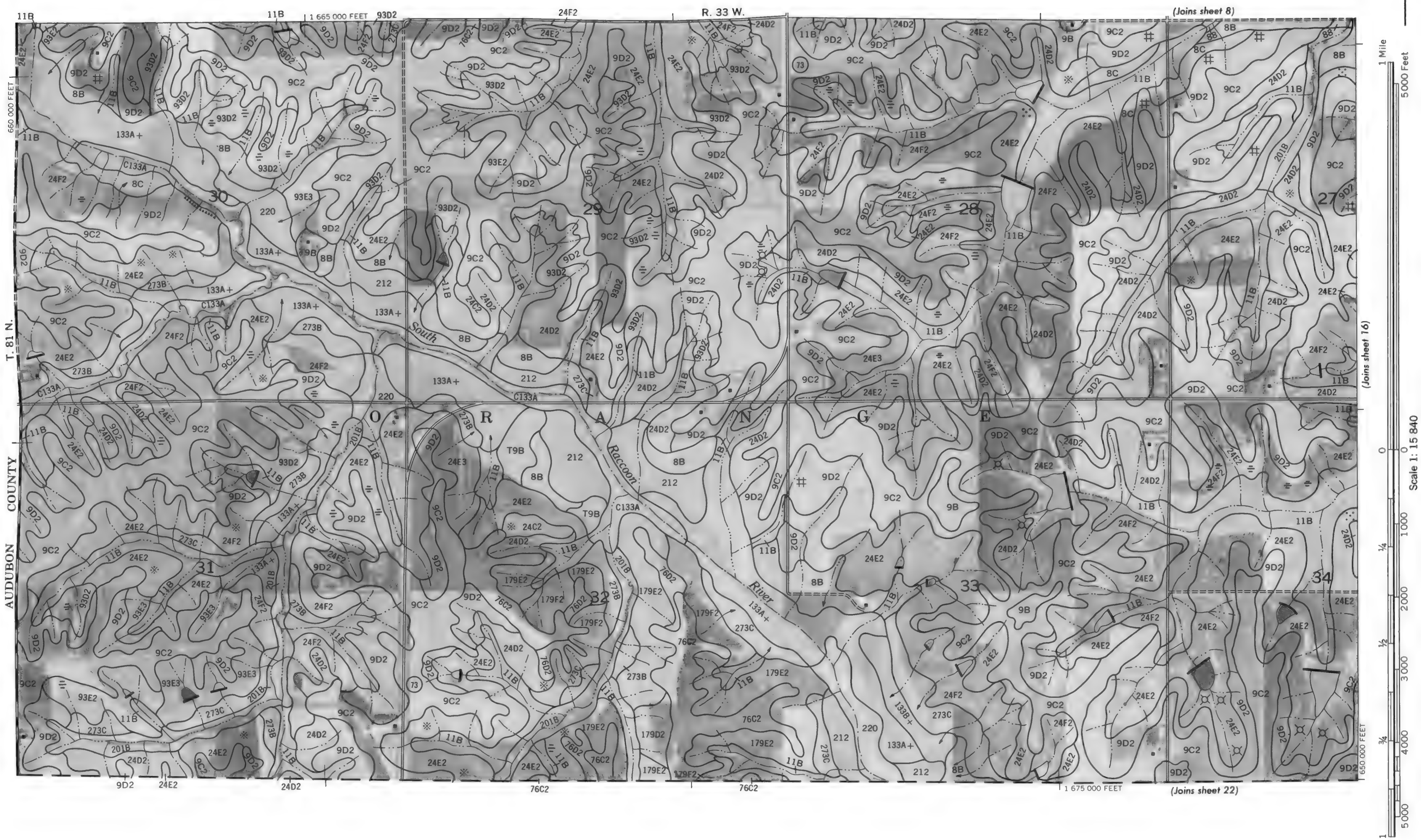


Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 14

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



GUTHRIE COUNTY, IOWA NO. 15

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

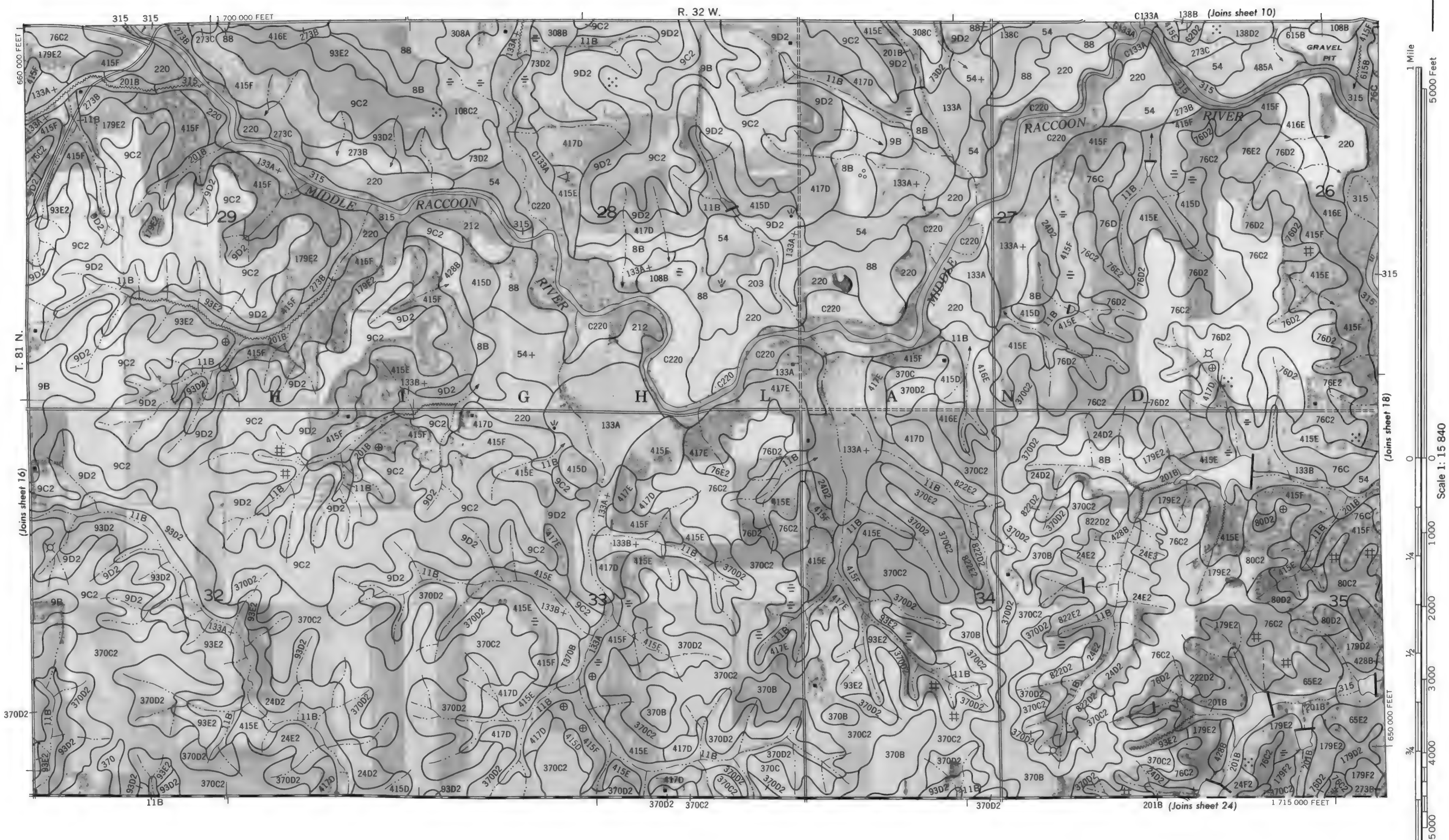
GUTHRIE COUNTY, IOWA — SHEET NUMBER 16

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 16

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



GUTHRIE COUNTY, IOWA NO. 17

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 18

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 18

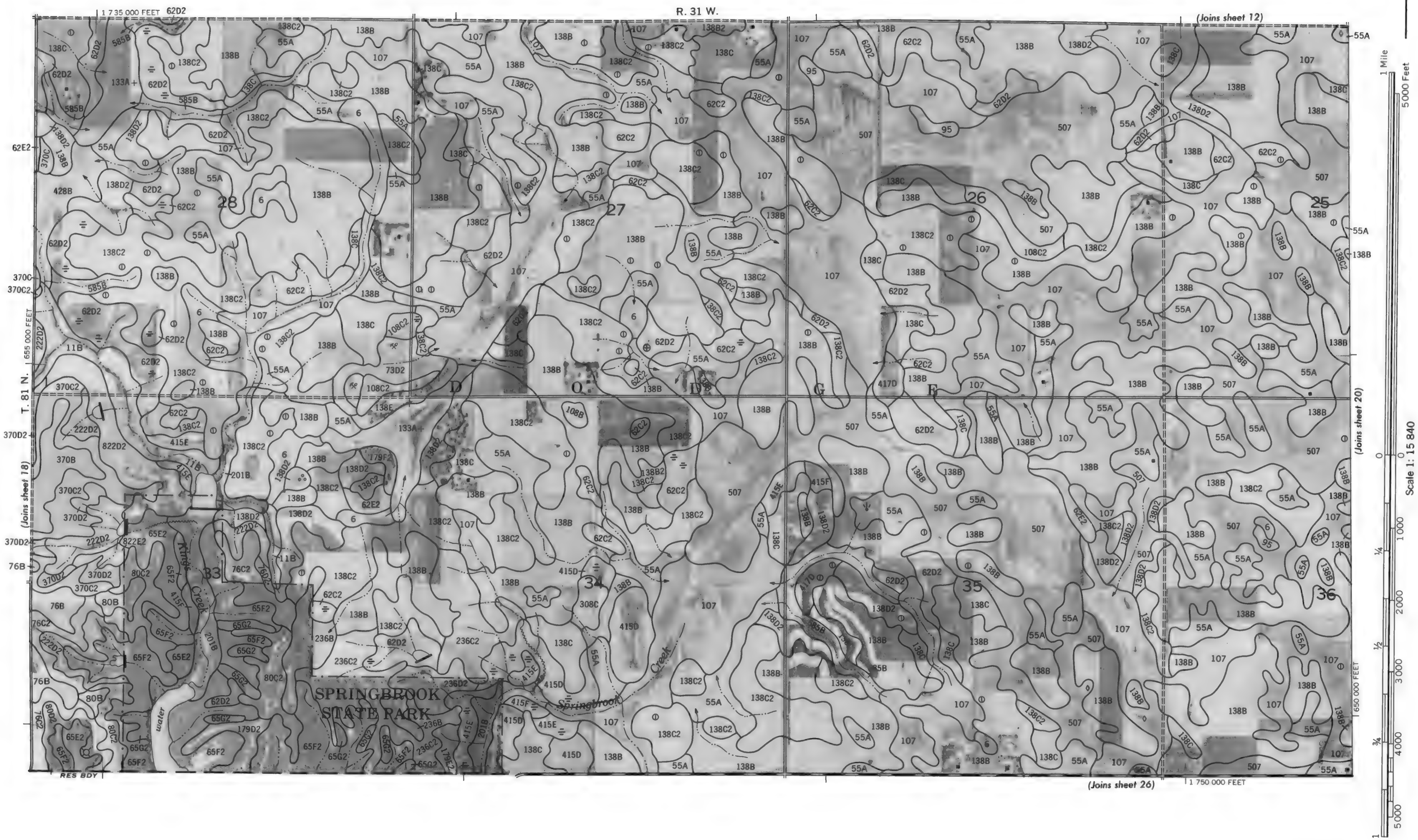
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

19

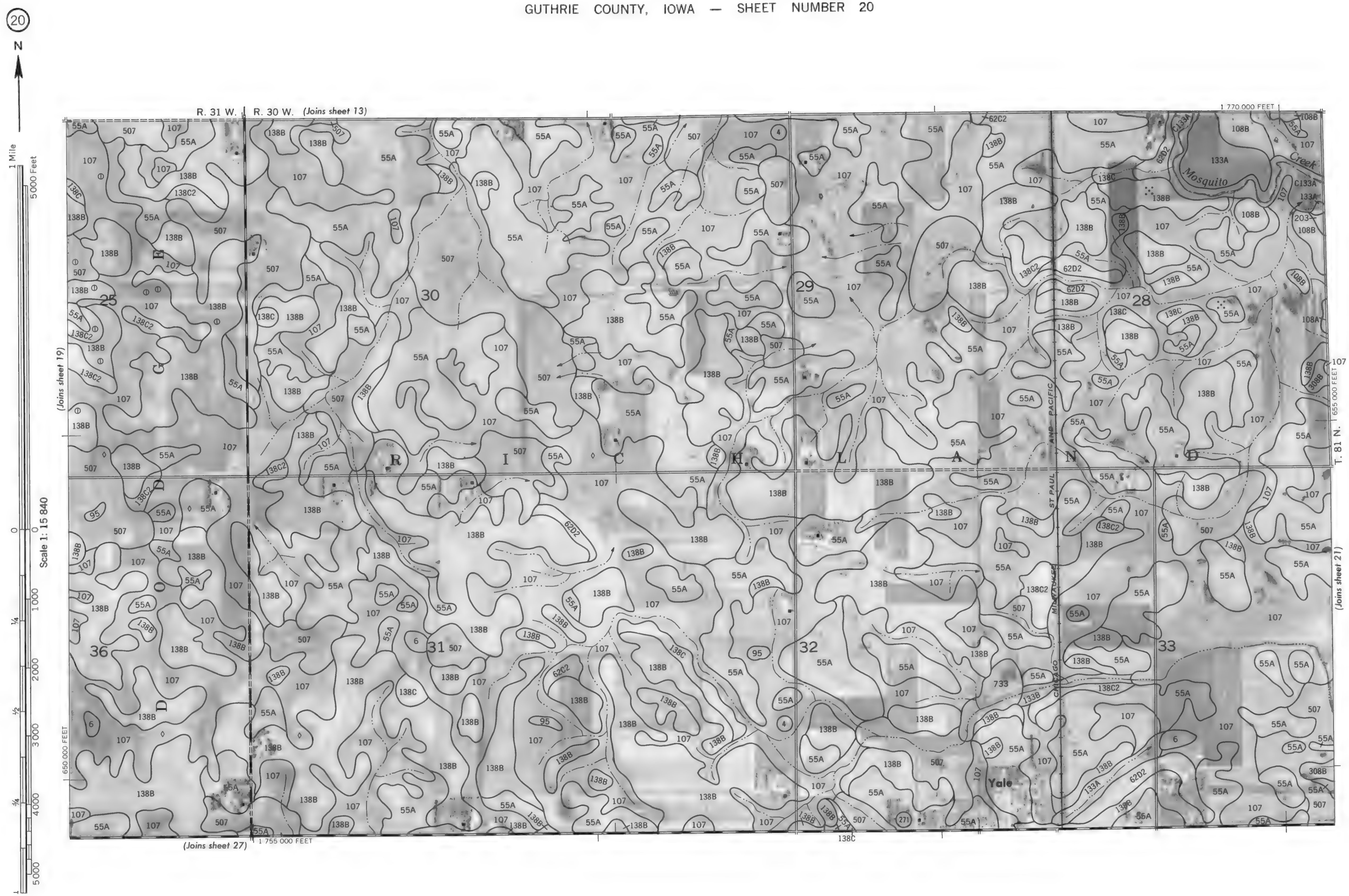
GUTHRIE COUNTY, IOWA NO. 19

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

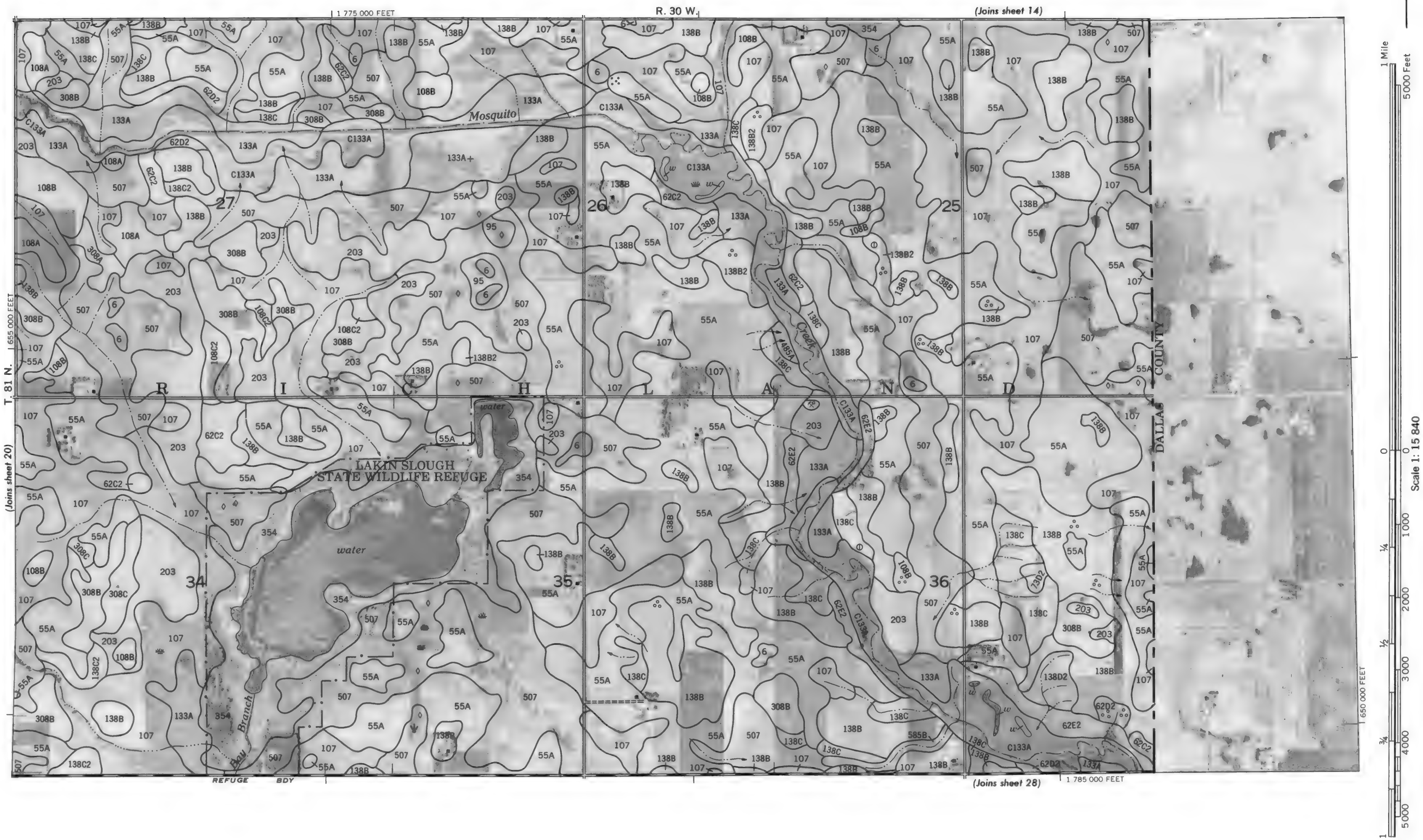
GUTHRIE COUNTY, IOWA NO. 20

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA NO. 21

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 22

N

Scale 1: 15 840

1 Mile

5000 Feet

4000 AND 5000-FOOT GRID TICKS

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

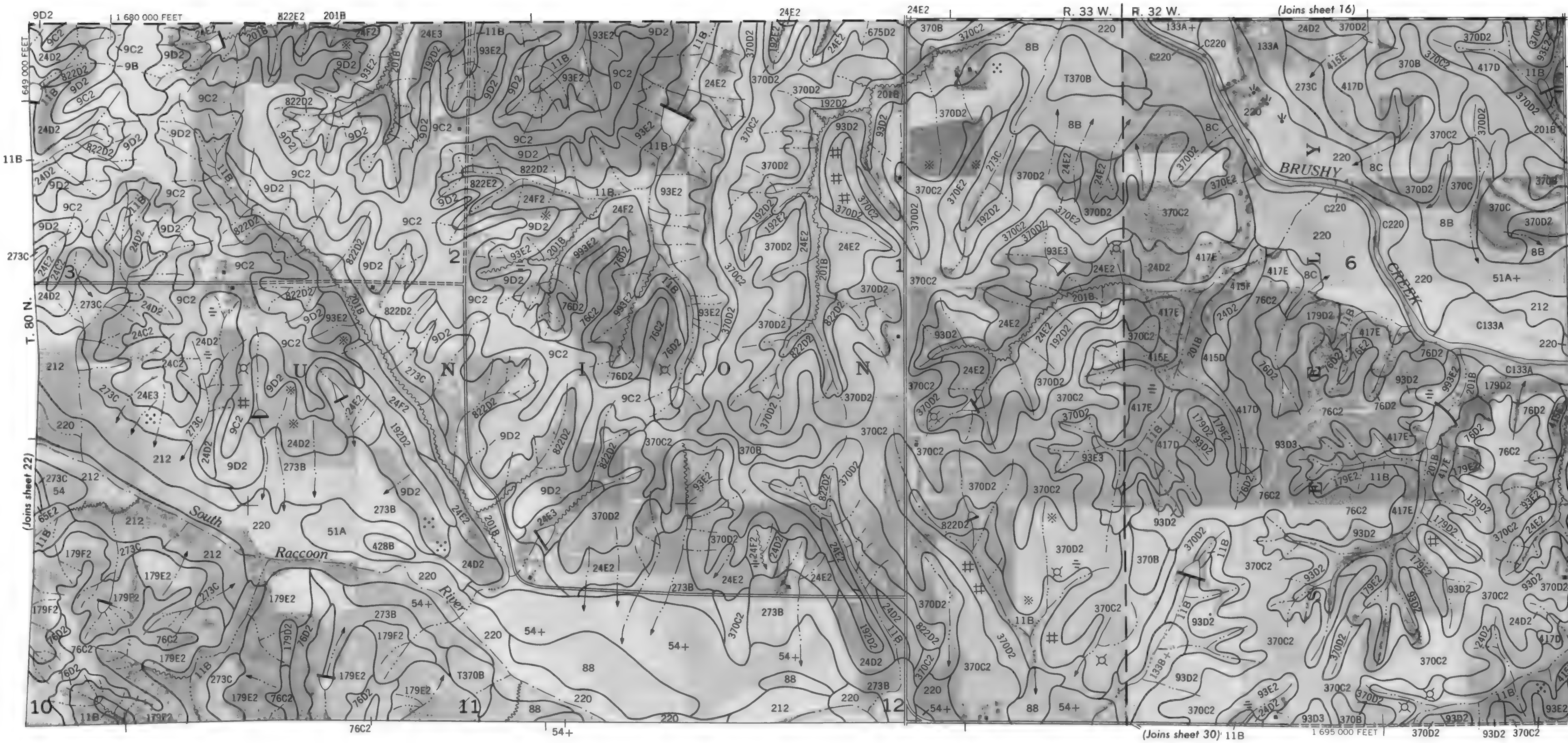
GUTHRIE COUNTY, IOWA NO. 22

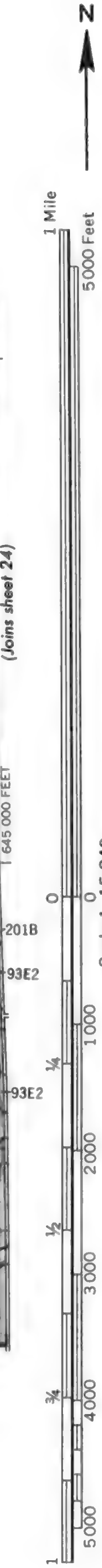
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA NO. 23

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.





4000 AND 5000-FOOT GRID TICKS

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

4000 AND 5000-FOOT GRID TICKS

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

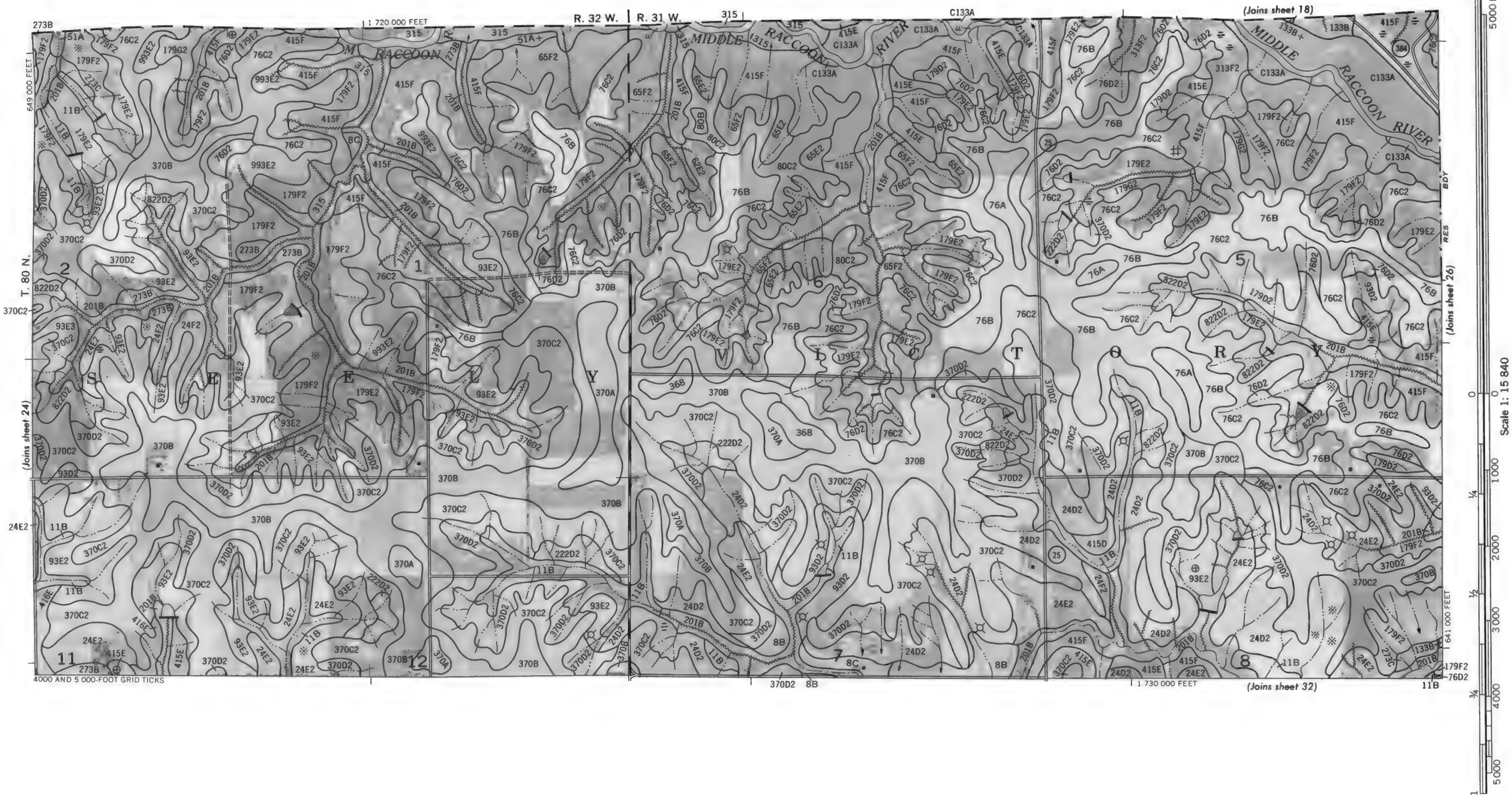
GUTHRIE COUNTY, IOWA NO. 24

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA NO. 25

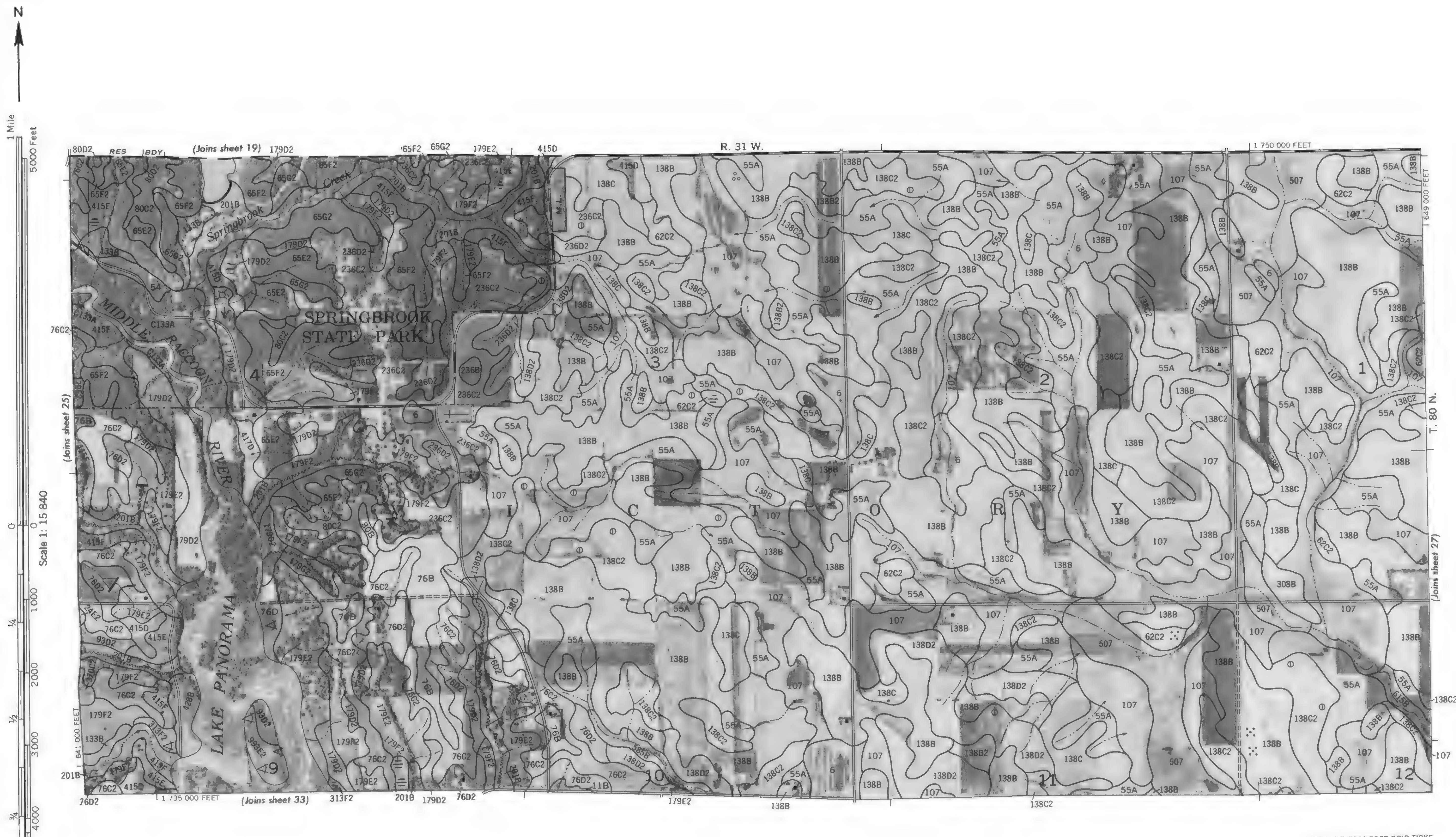
This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 26



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 26

GUTHRIE COUNTY, IOWA NO. 27

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

4000 AND 5000-FOOT GRID TICKS INTERVAL

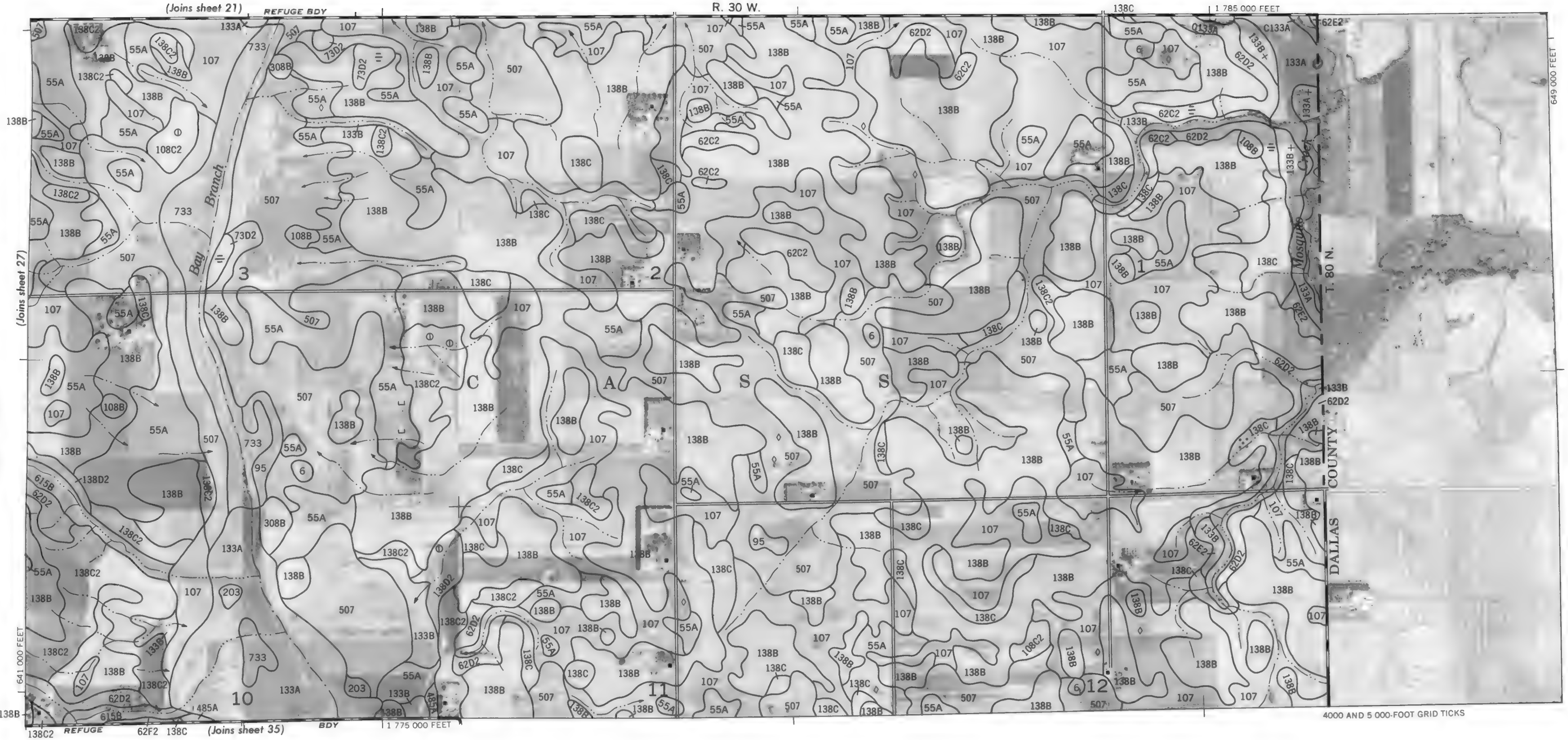
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

(28)

N

1 Mile 5000 Feet

Scale 1: 15 840



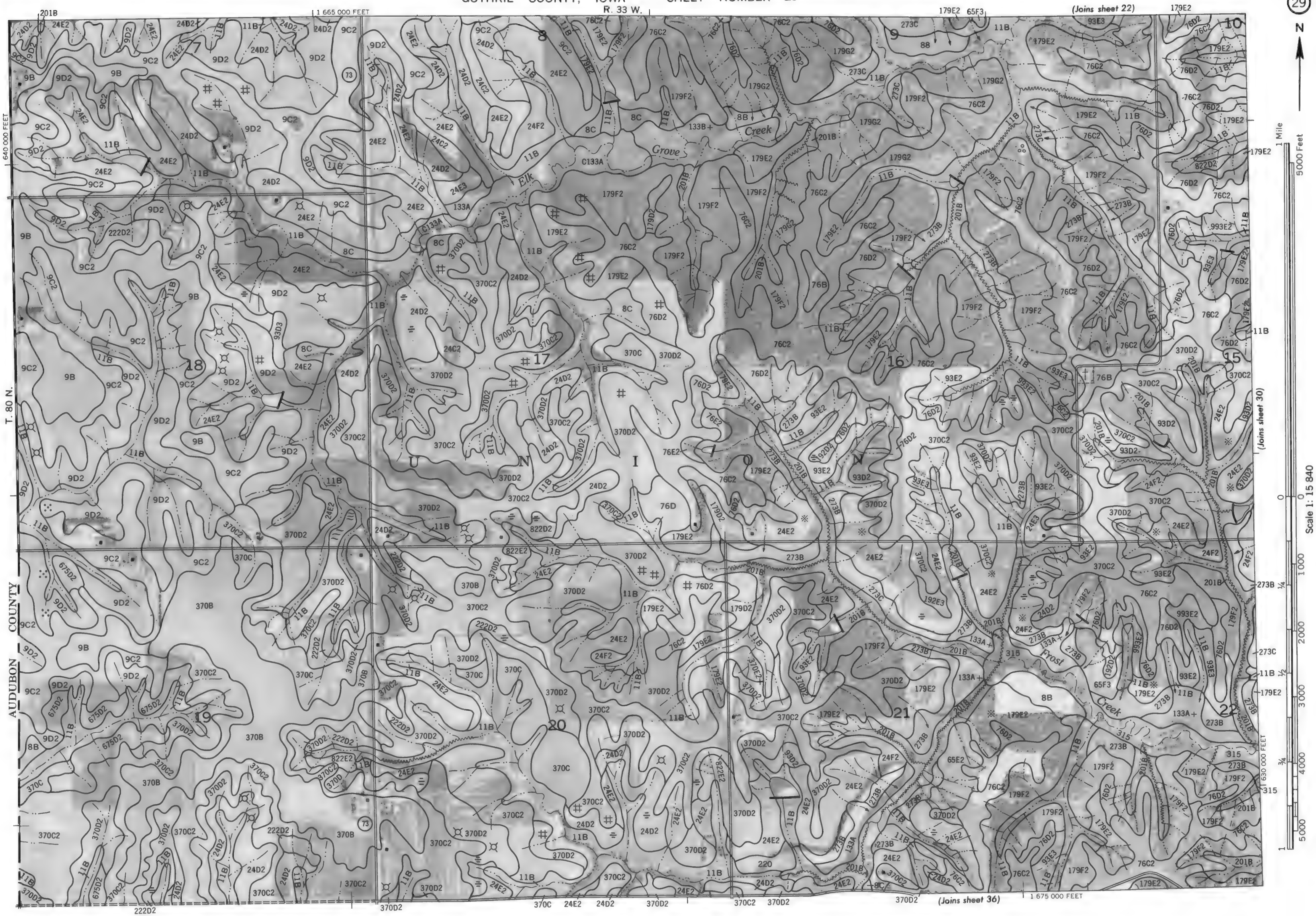
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 28

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

29



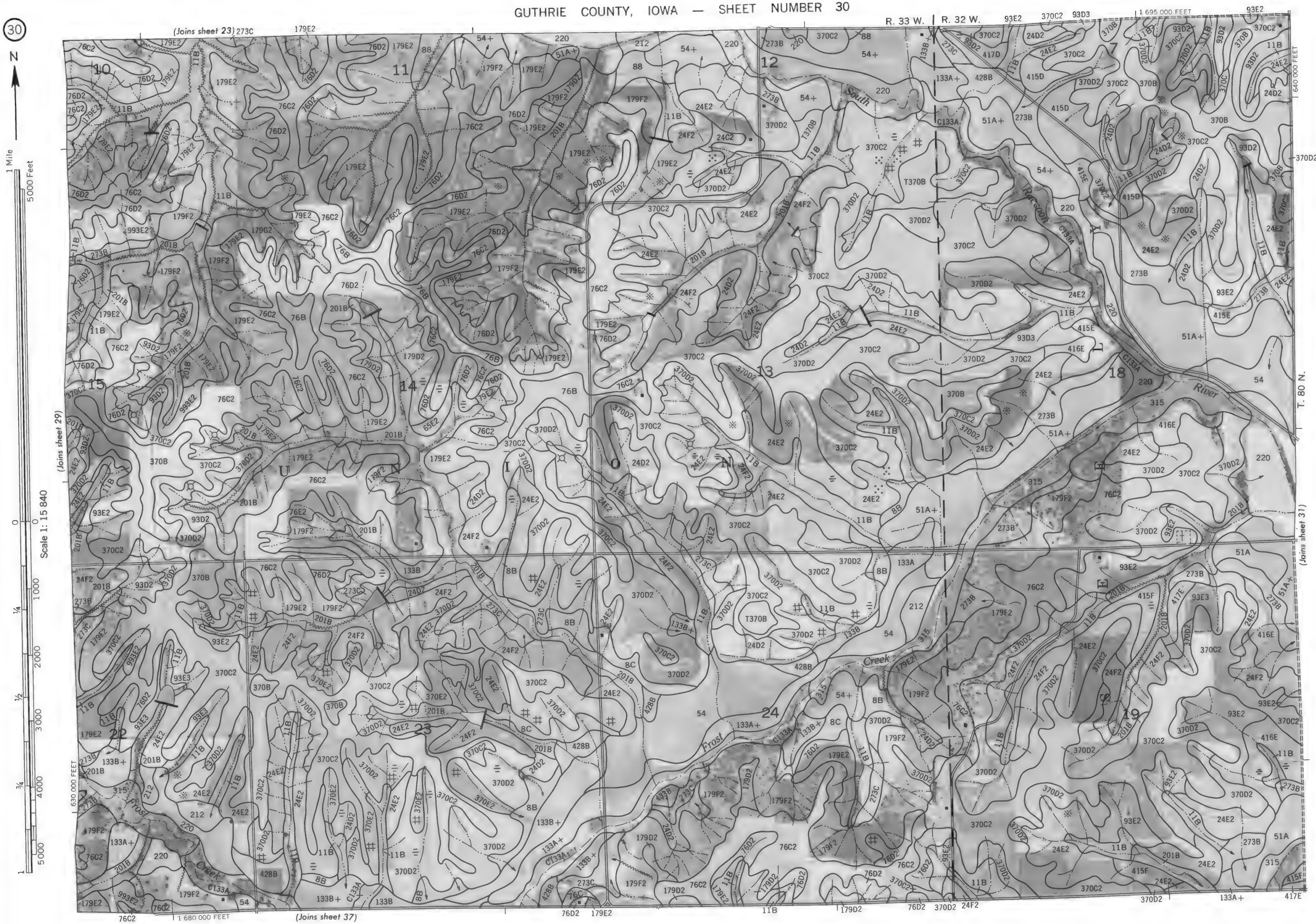
GUTHRIE COUNTY, IOWA NO. 29

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 30



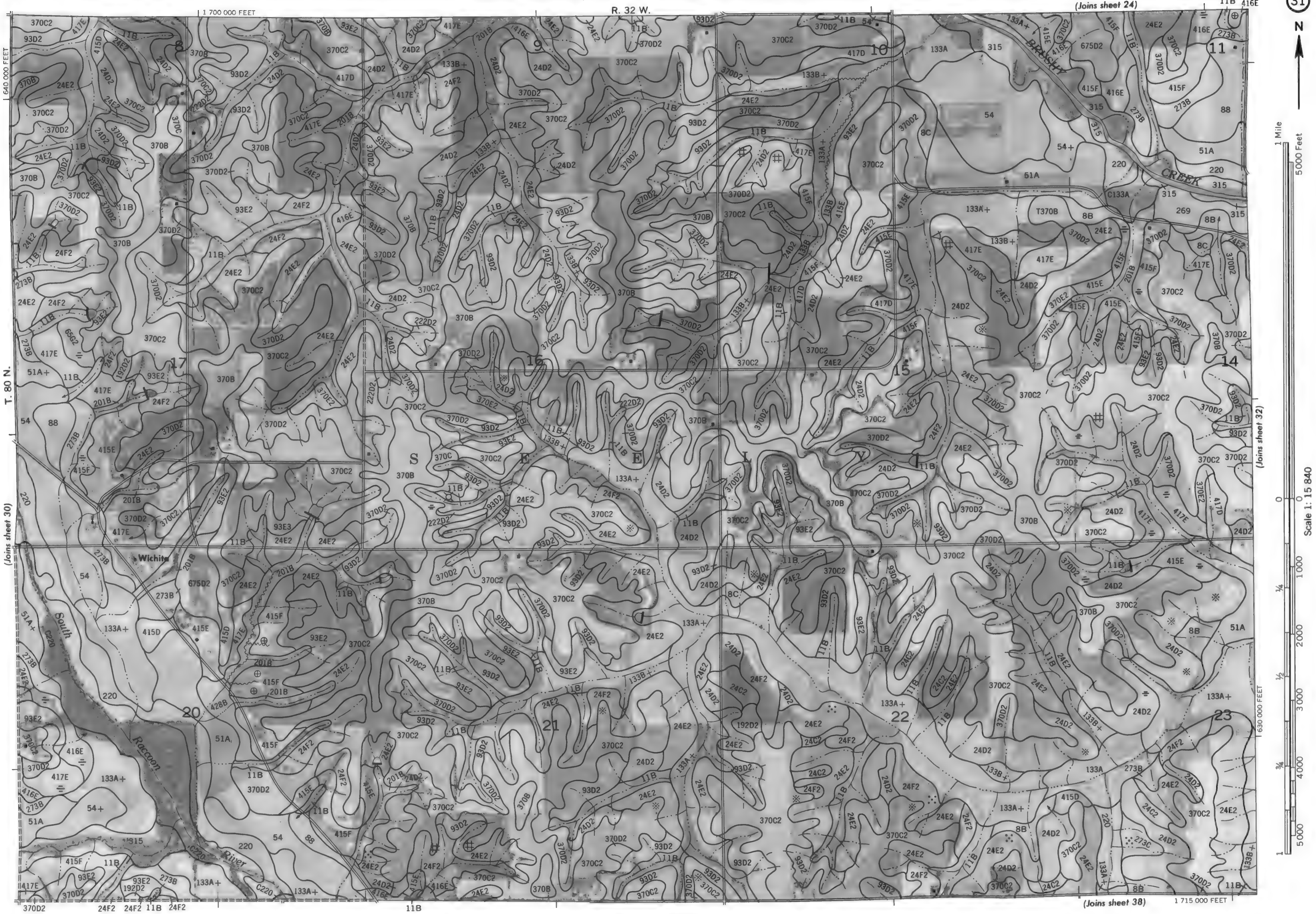
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 30

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 31



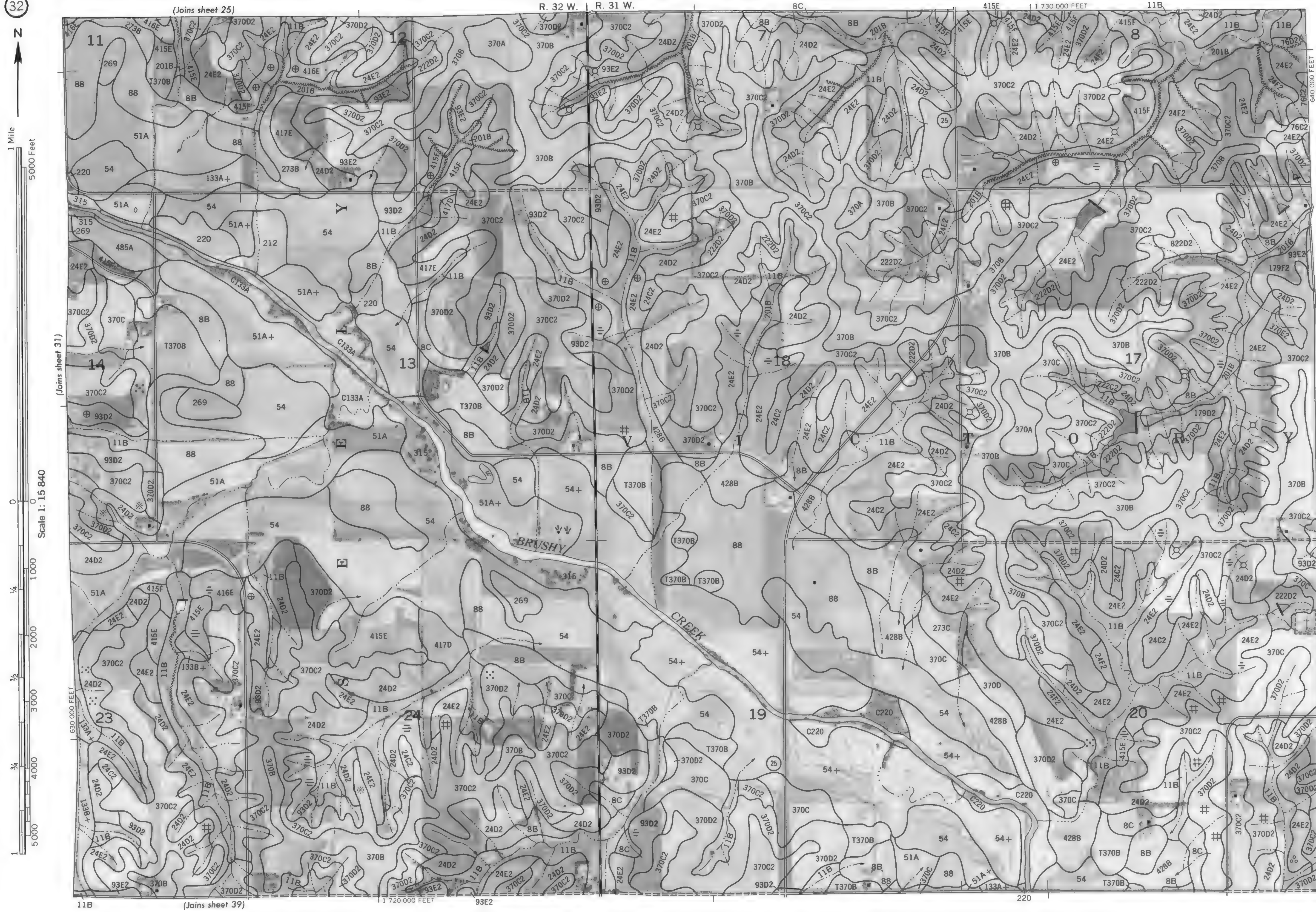
GUTHRIE COUNTY, IOWA NO. 31

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 32



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 33

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

N

1 Mile
5000 Feet
0
1000
2000
3000
4000
5000
0
¼
½
¾
1
Scale 1:15 840

GUTHRIE COUNTY, IOWA — SHEET NUMBER 34

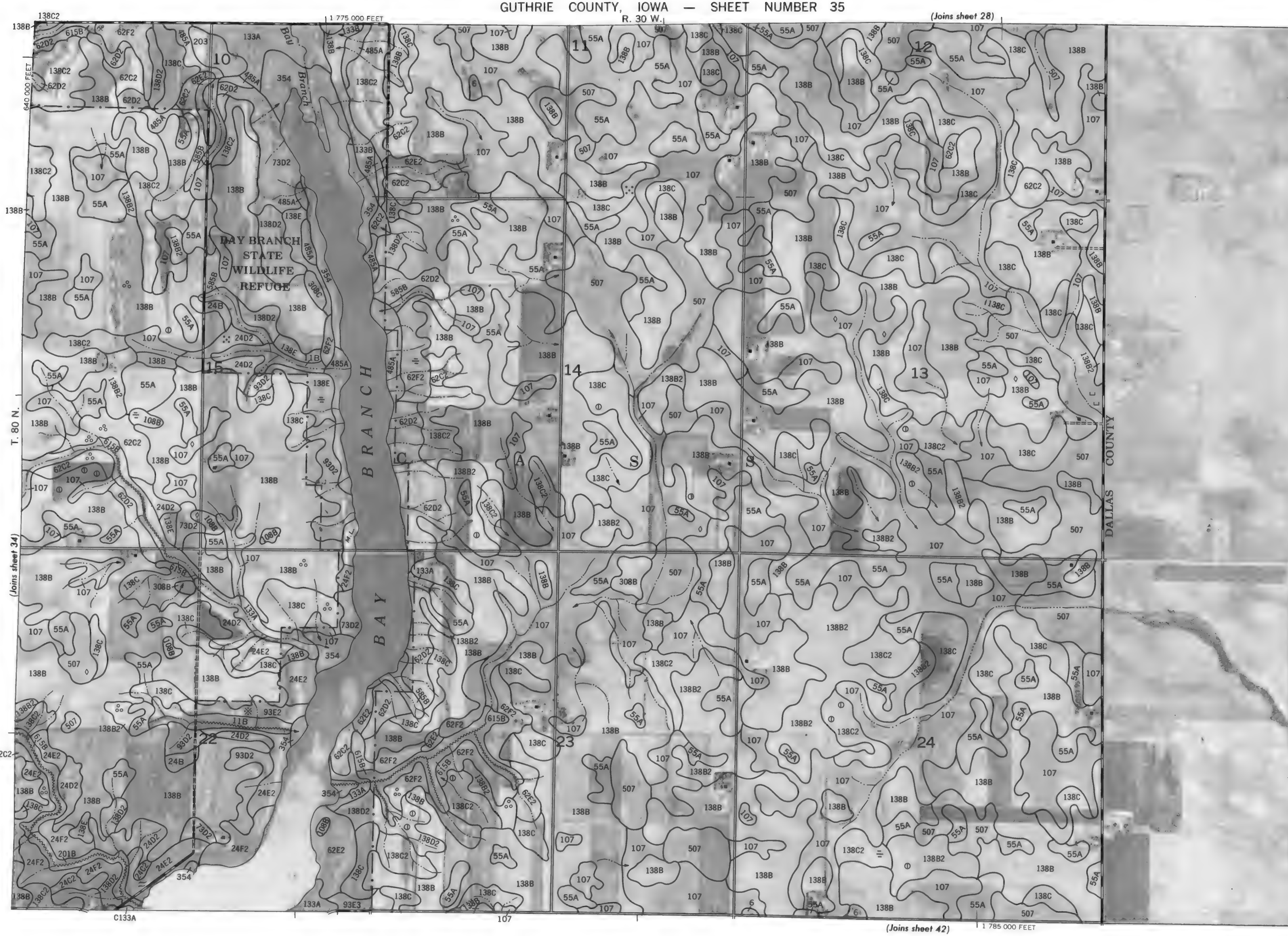
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA NO. 34

GUTHRIE COUNTY, IOWA — SHEET NUMBER 35



35

N

Scale 1: 15 840

1 Mile

5000 Feet

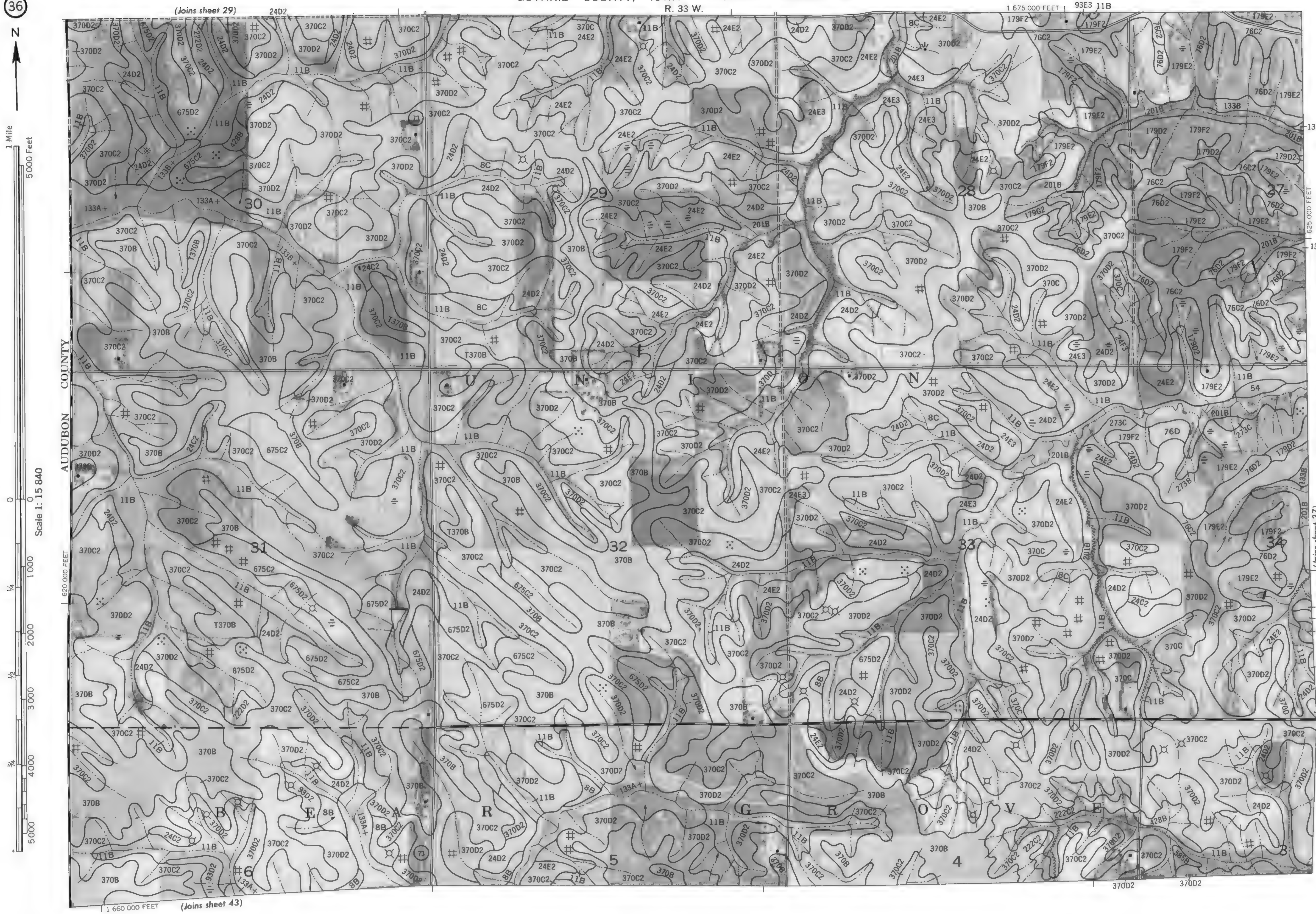
GUTHRIE COUNTY, IOWA NO. 35

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

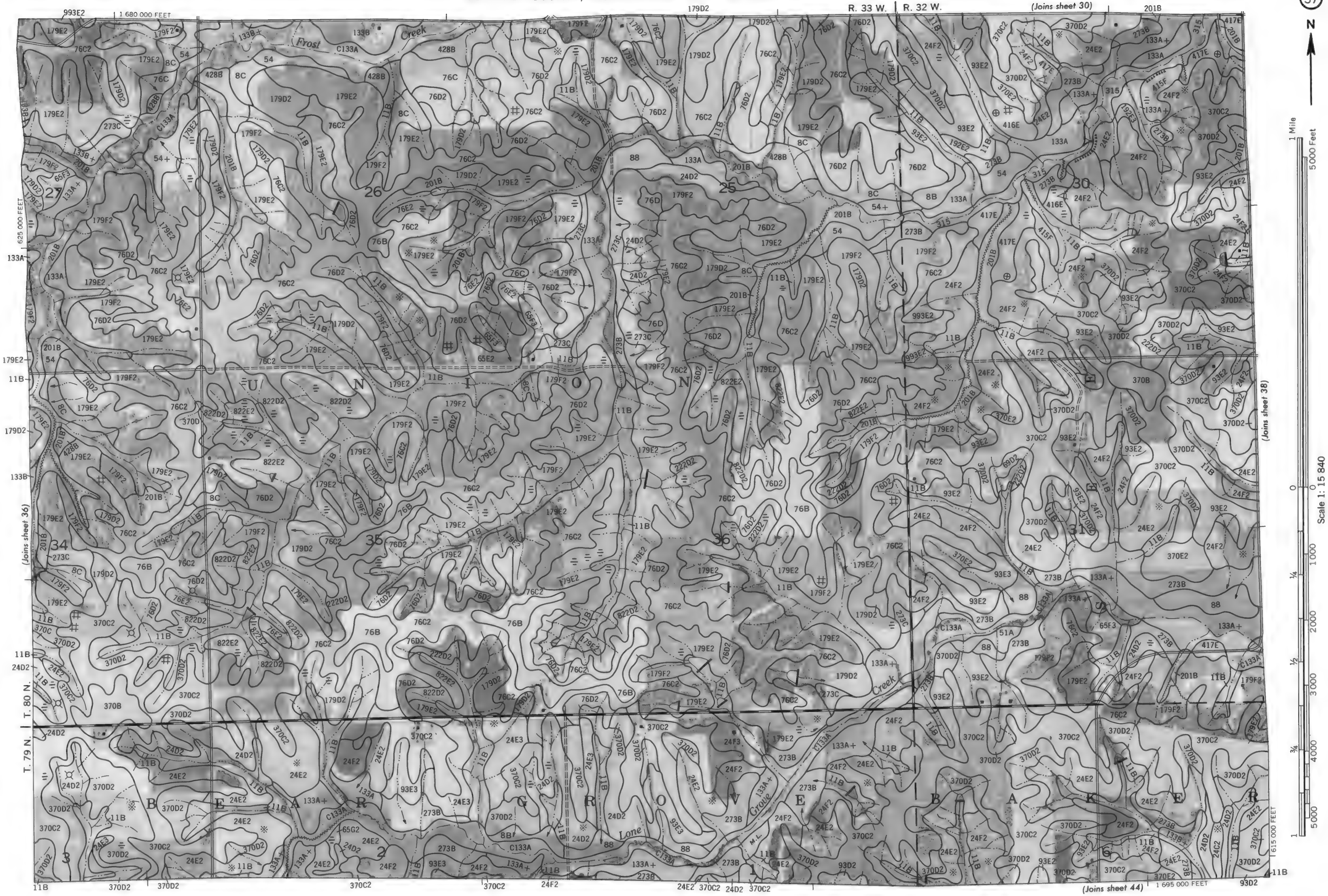
GUTHRIE COUNTY, IOWA — SHEET NUMBER 36



Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



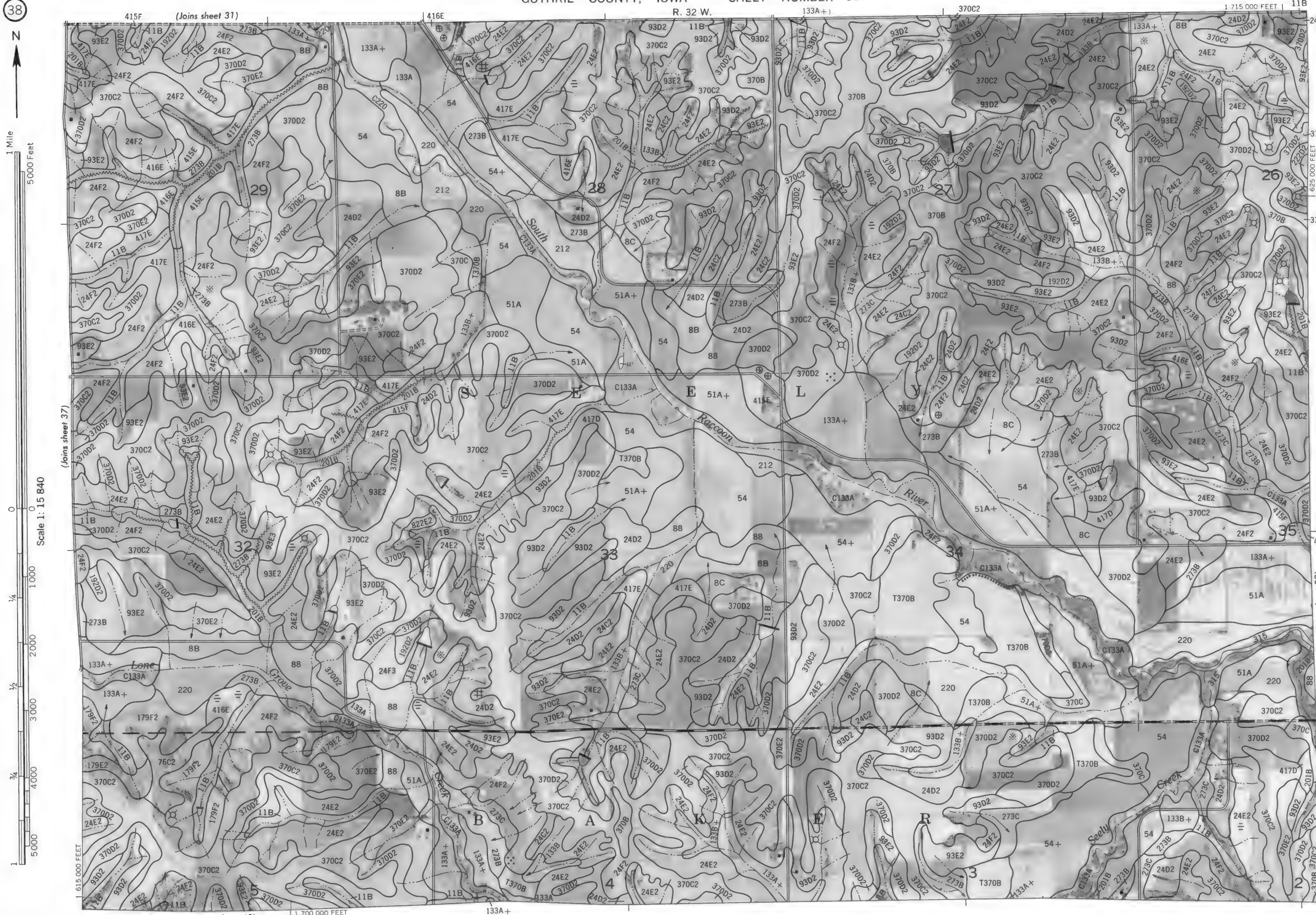
GUTHRIE COUNTY, IOWA NO. 37

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 38



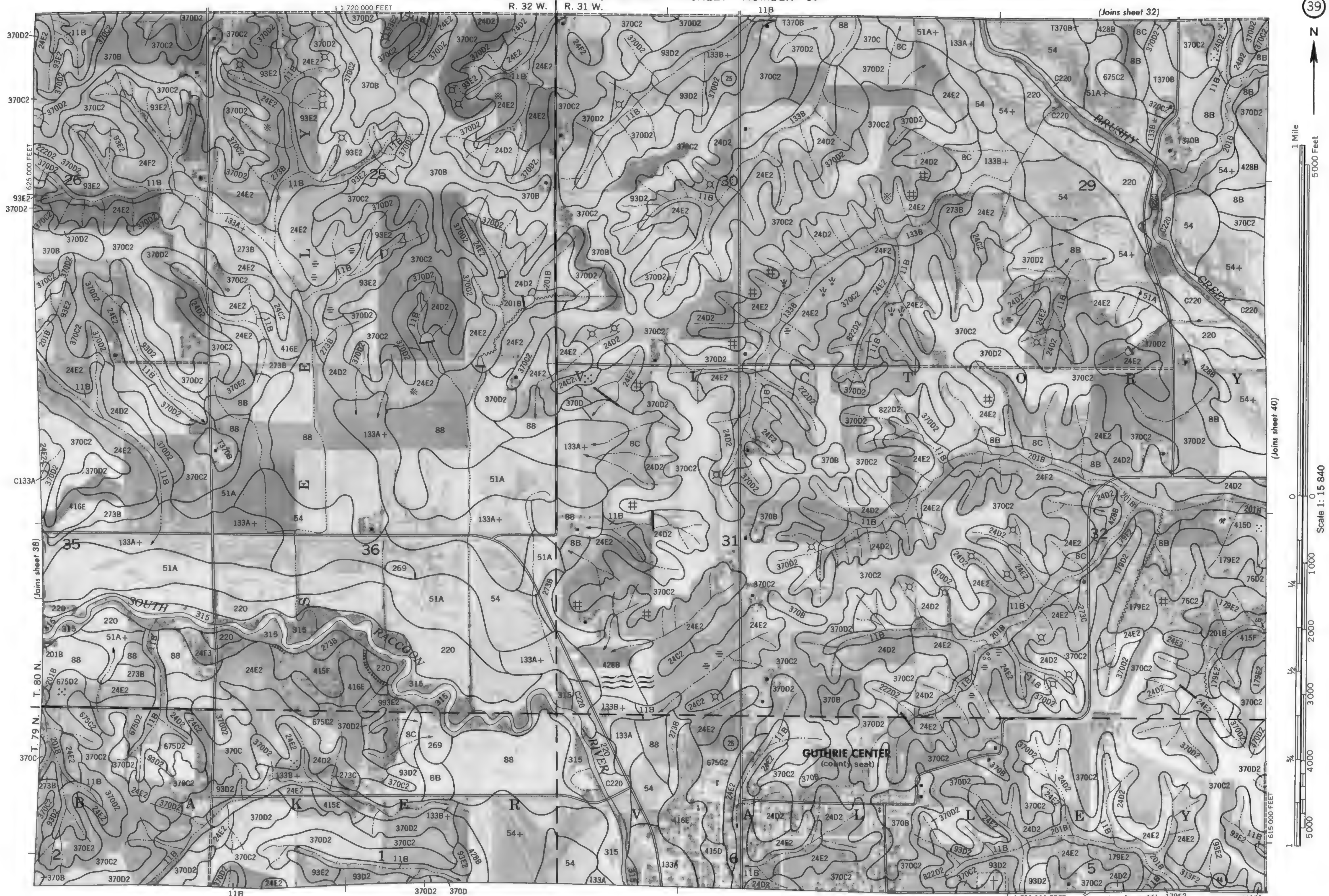
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 38

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 39



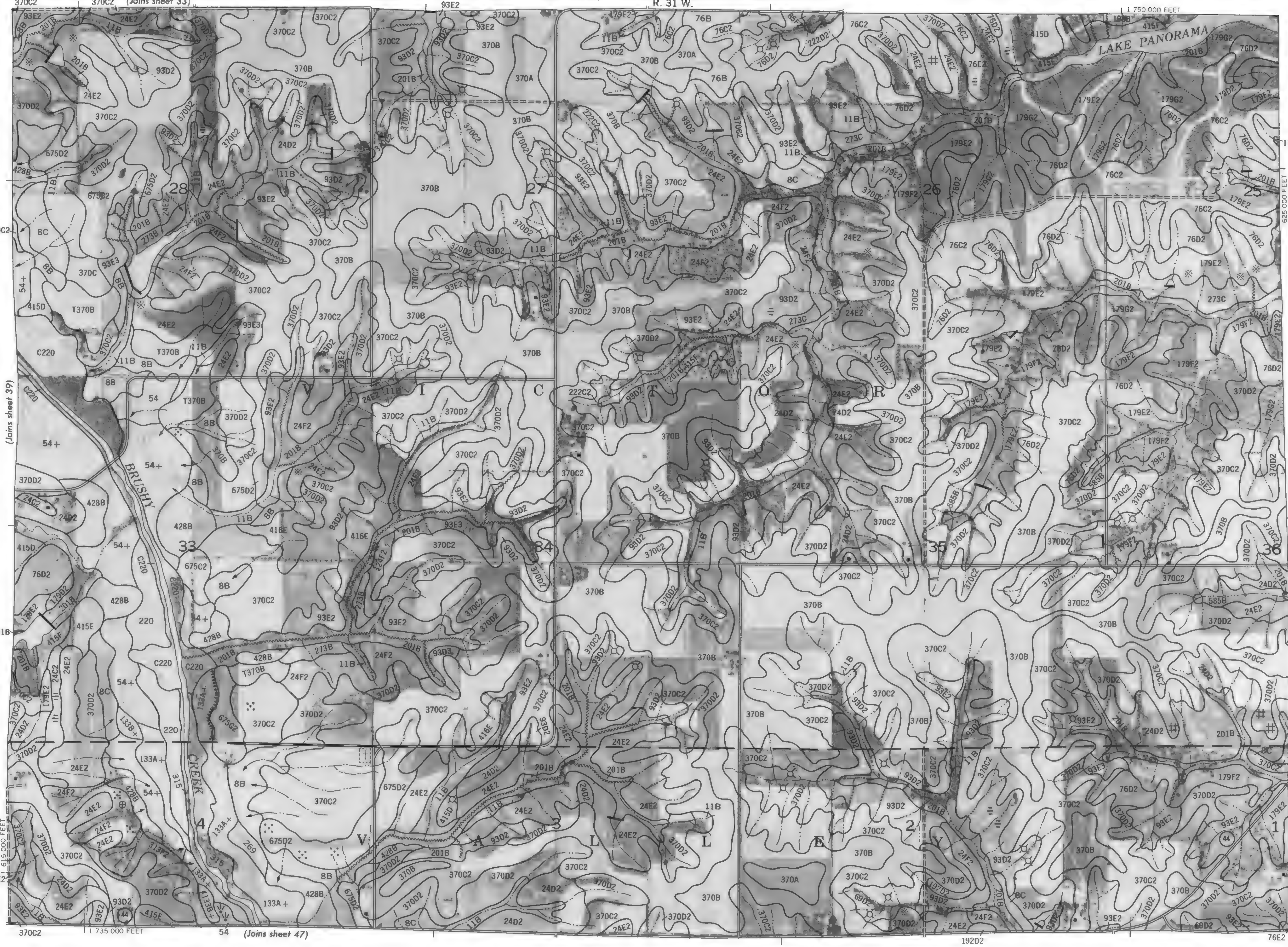
GUTHRIE COUNTY, IOWA NO. 39

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 40



Scale 1: 15 840

1 Mile

5000 Feet

0 1/4 1/2 3/4 1

0 1000 2000 3000 4000 5000

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 40

GUTHRIE COUNTY, IOWA — SHEET NUMBER 41

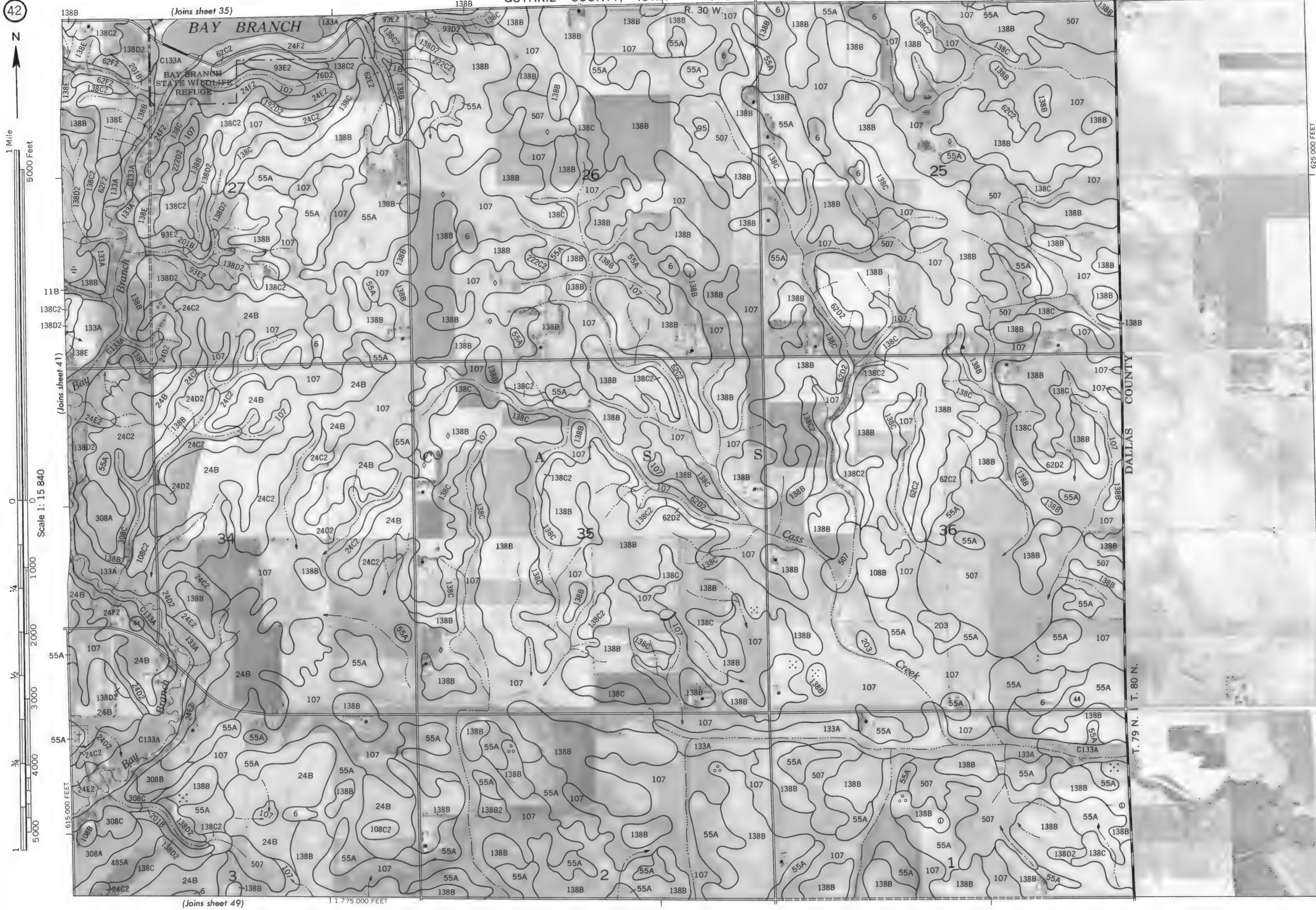
GUTHRIE COUNTY, IOWA NO. 41

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 42



Land division corners are approximately positioned on this map.

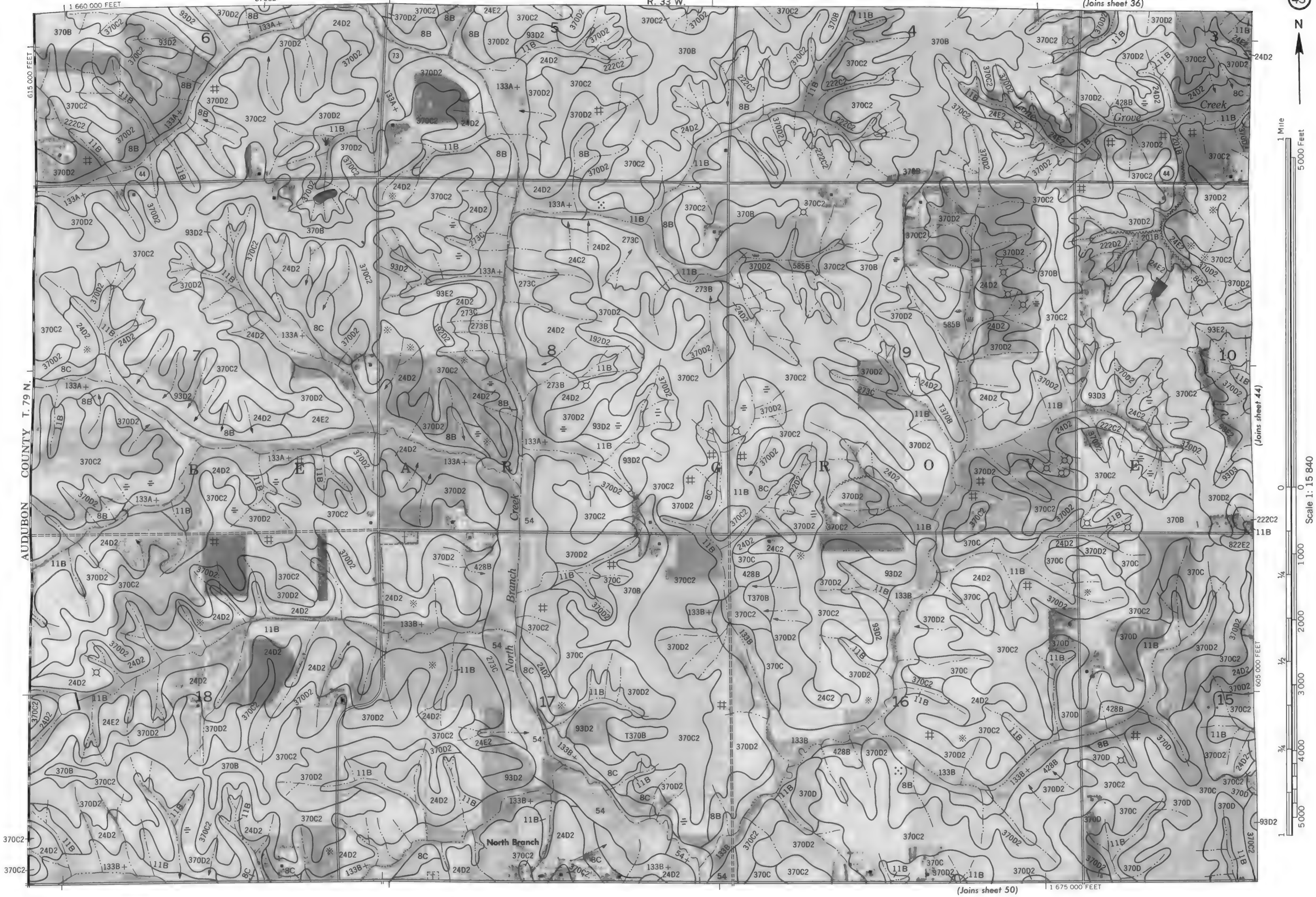
This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA NO. 42

GUTHRIE COUNTY, IOWA — SHEET NUMBER 43

43

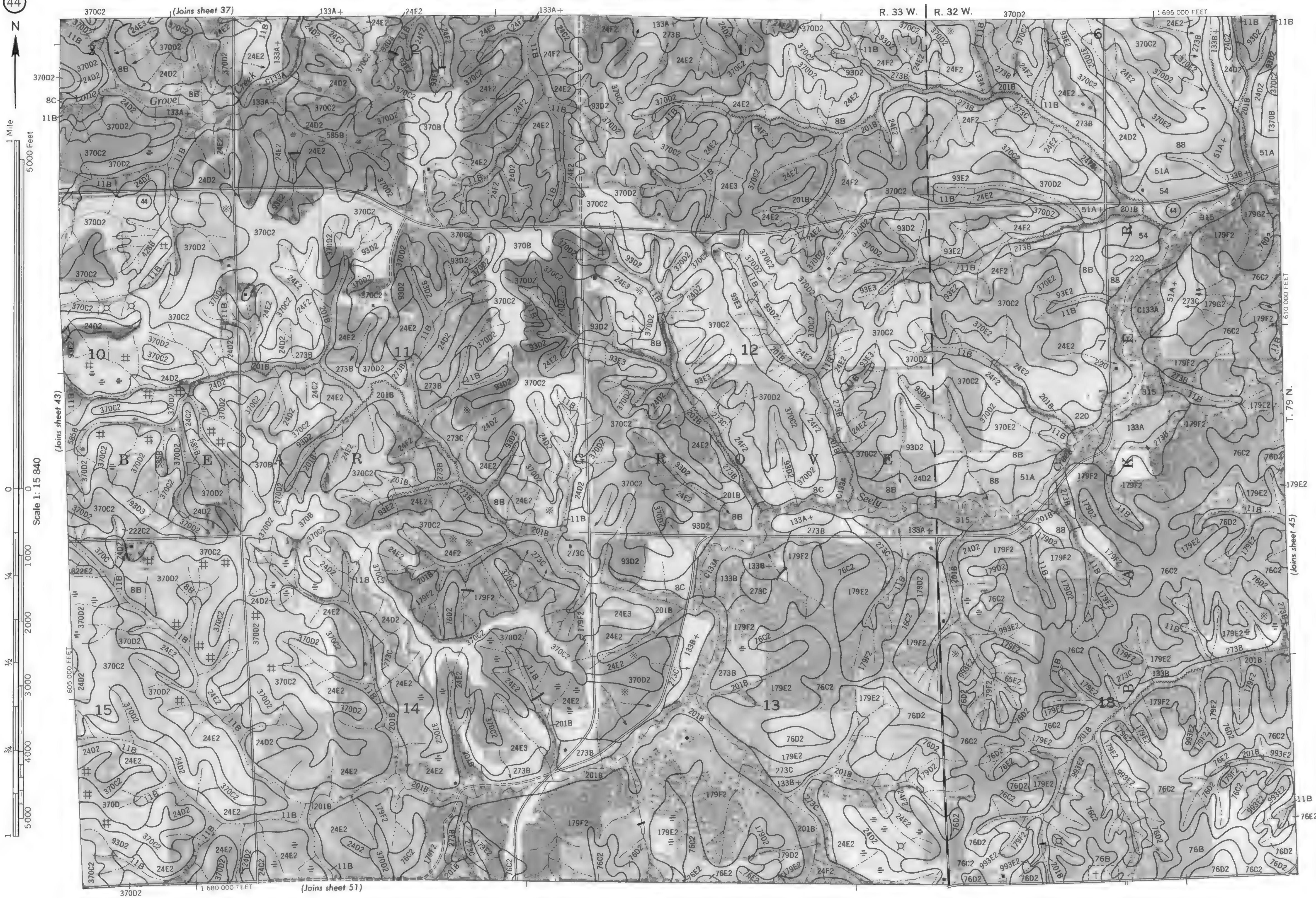


GUTHRIE COUNTY, IOWA NO. 43

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

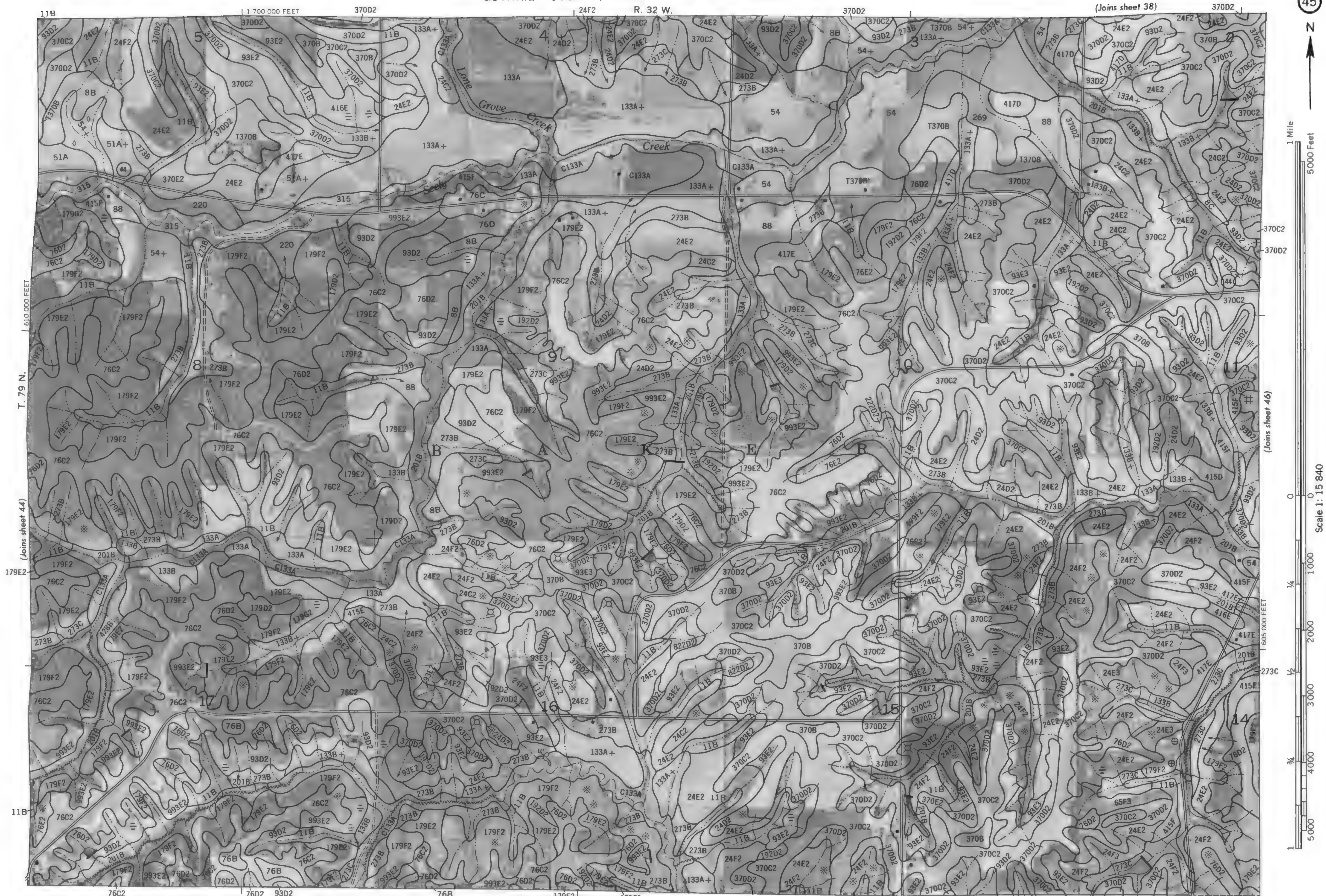


Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa

GUTHRIE COUNTY, IOWA — SHEET NUMBER 45



GUTHRIE COUNTY, IOWA NO. 45

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 46

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa

GUTHRIE COUNTY, IOWA NO. 46

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

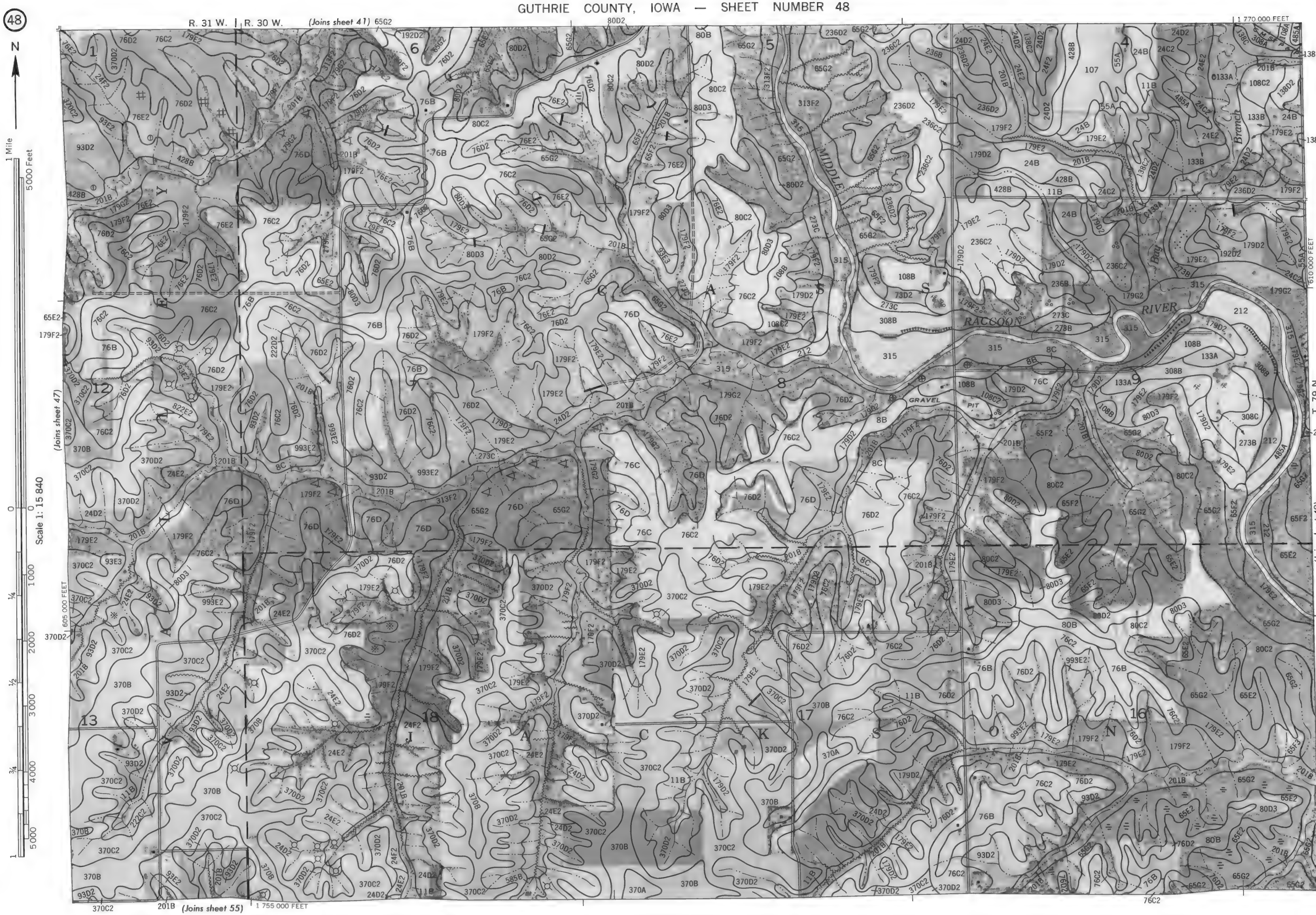
GUTHRIE COUNTY, IOWA NO. 47

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa

Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 48



Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA NO. 48

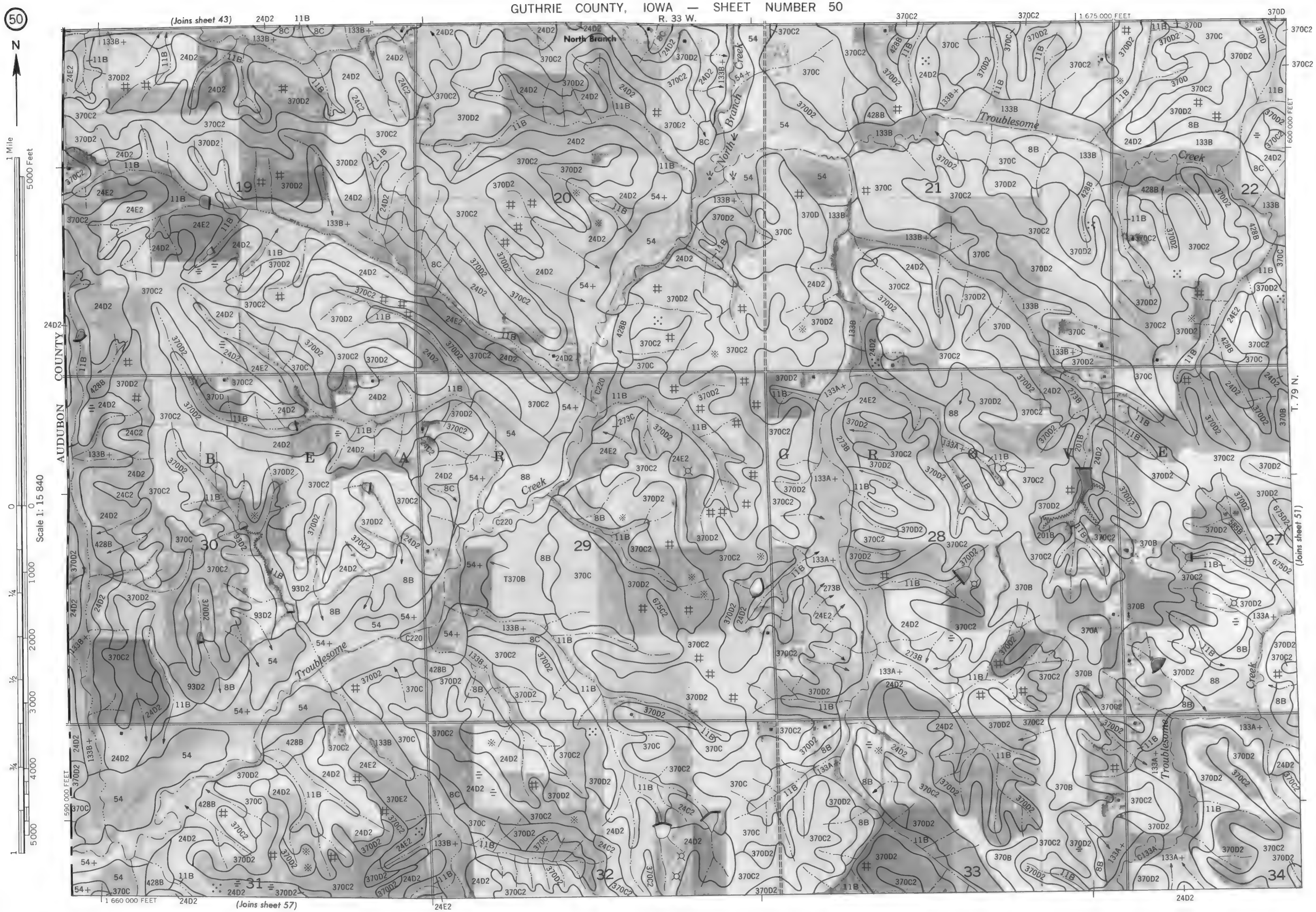
GUTHRIE COUNTY, IOWA NO. 49

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 50



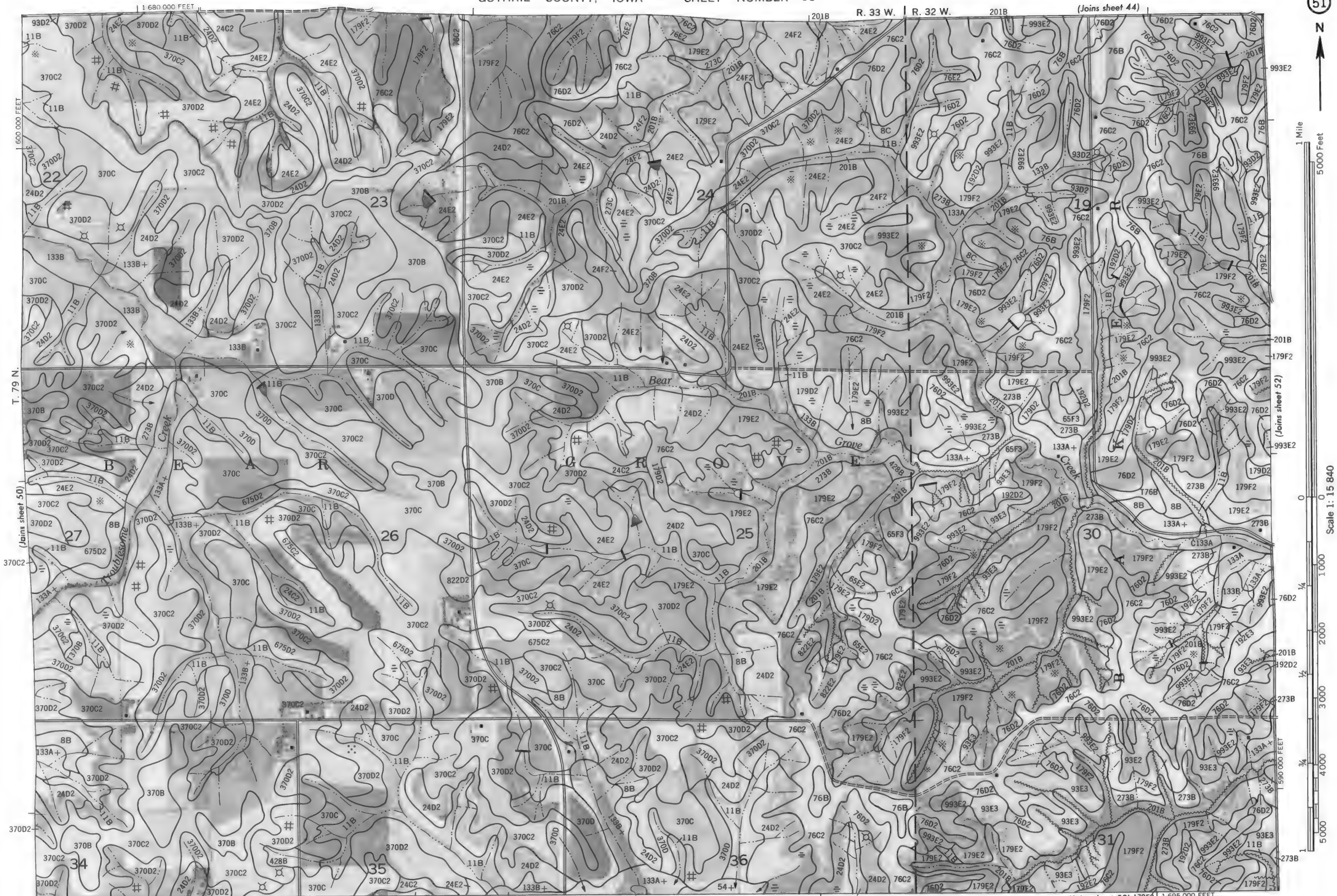
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA NO. 50

GUTHRIE COUNTY, IOWA — SHEET NUMBER 51

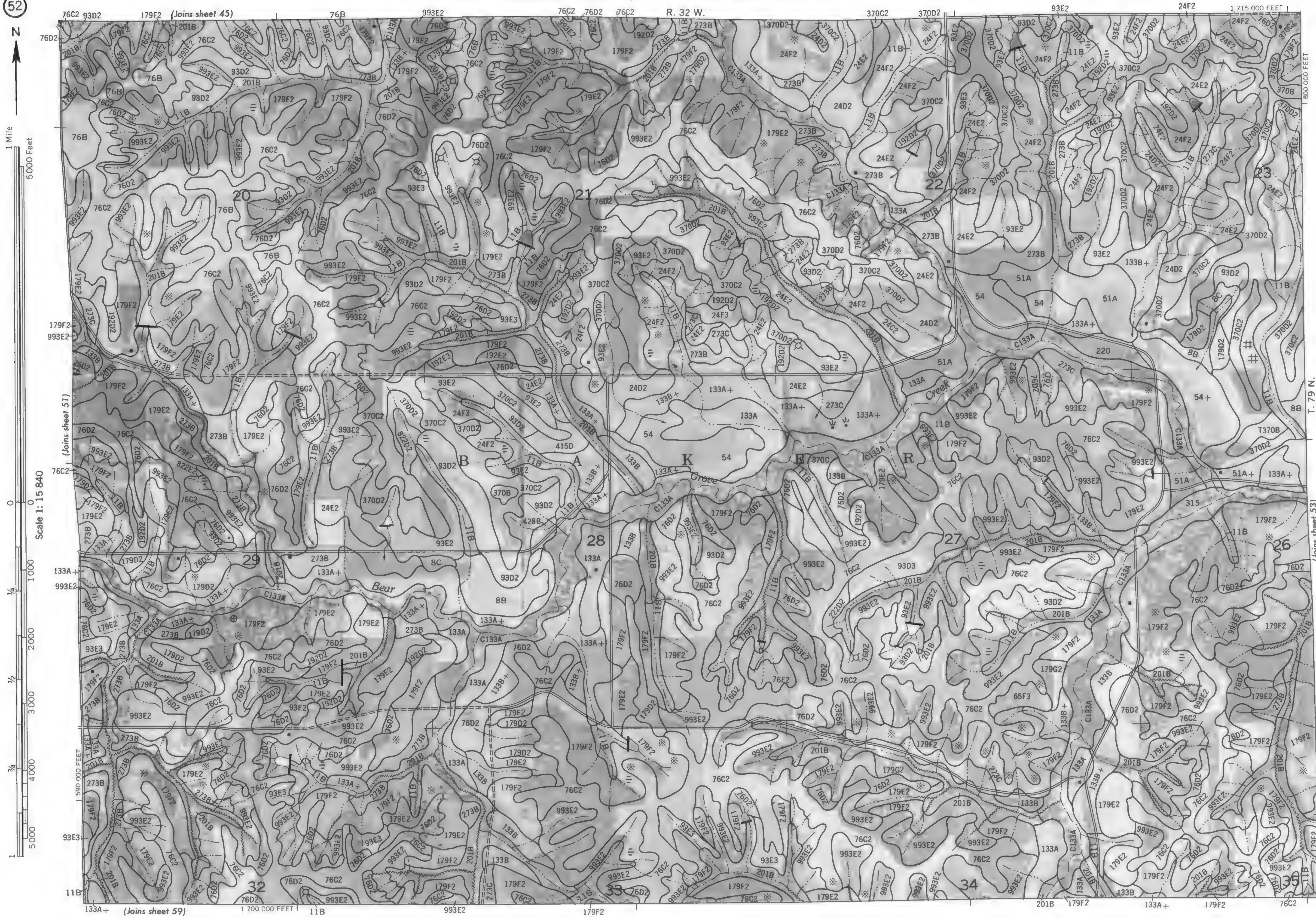


GUTHRIE COUNTY, IOWA NO. 51

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

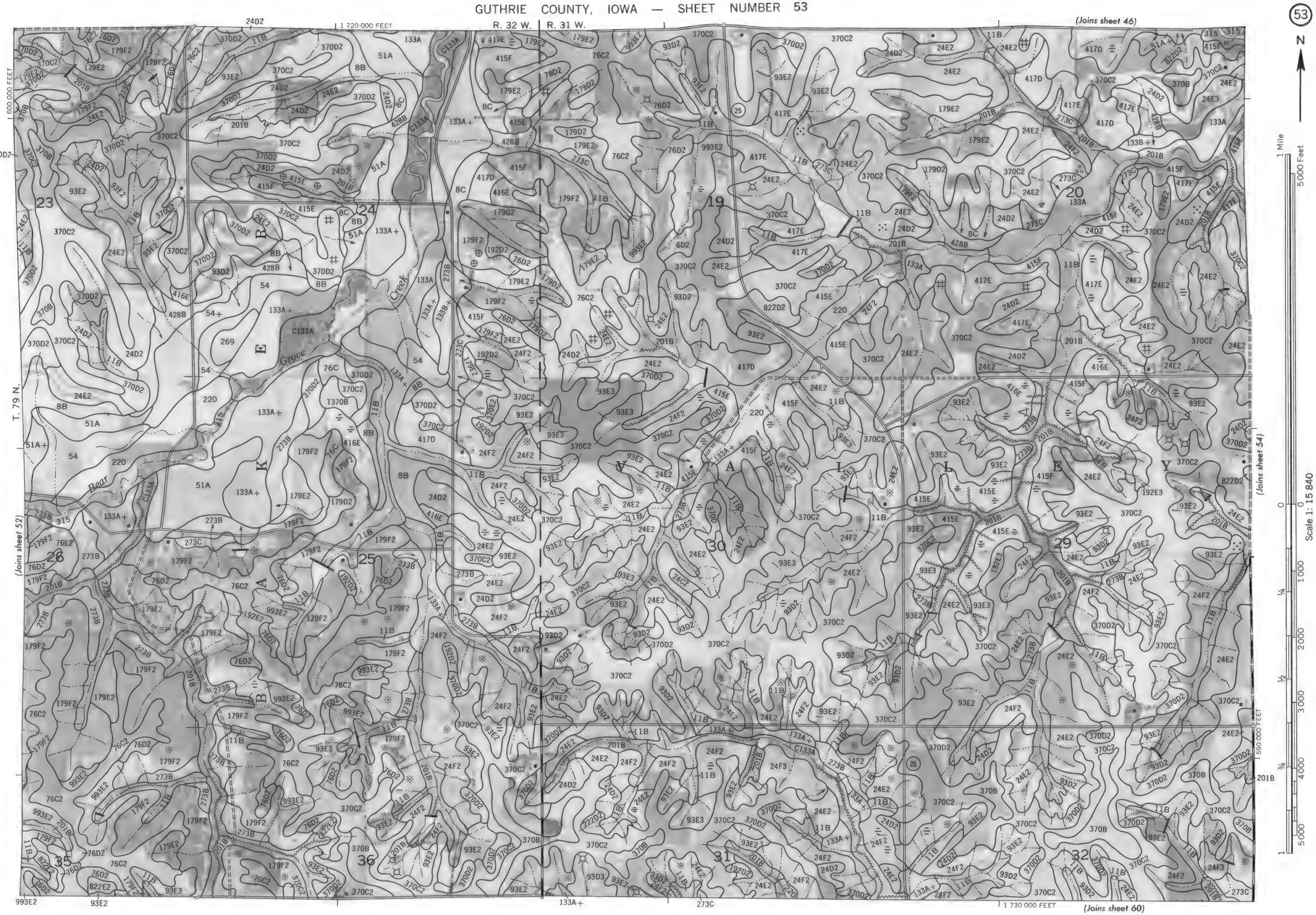
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone



Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



GUTHRIE COUNTY, IOWA NO. 53

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

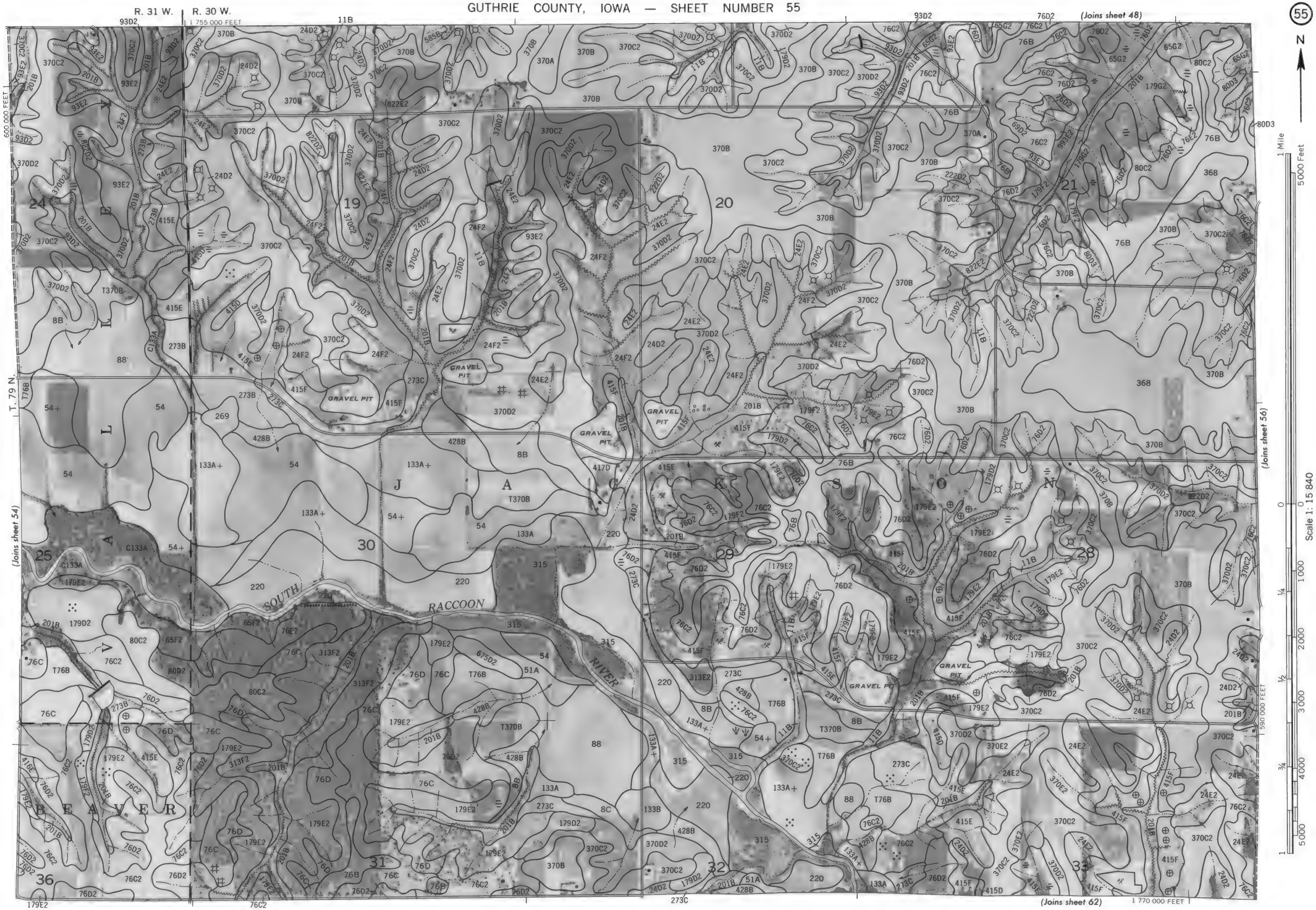
GUTHRIE COUNTY, IOWA — SHEET NUMBER 54

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 54



GUTHRIE COUNTY, IOWA NO. 55

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

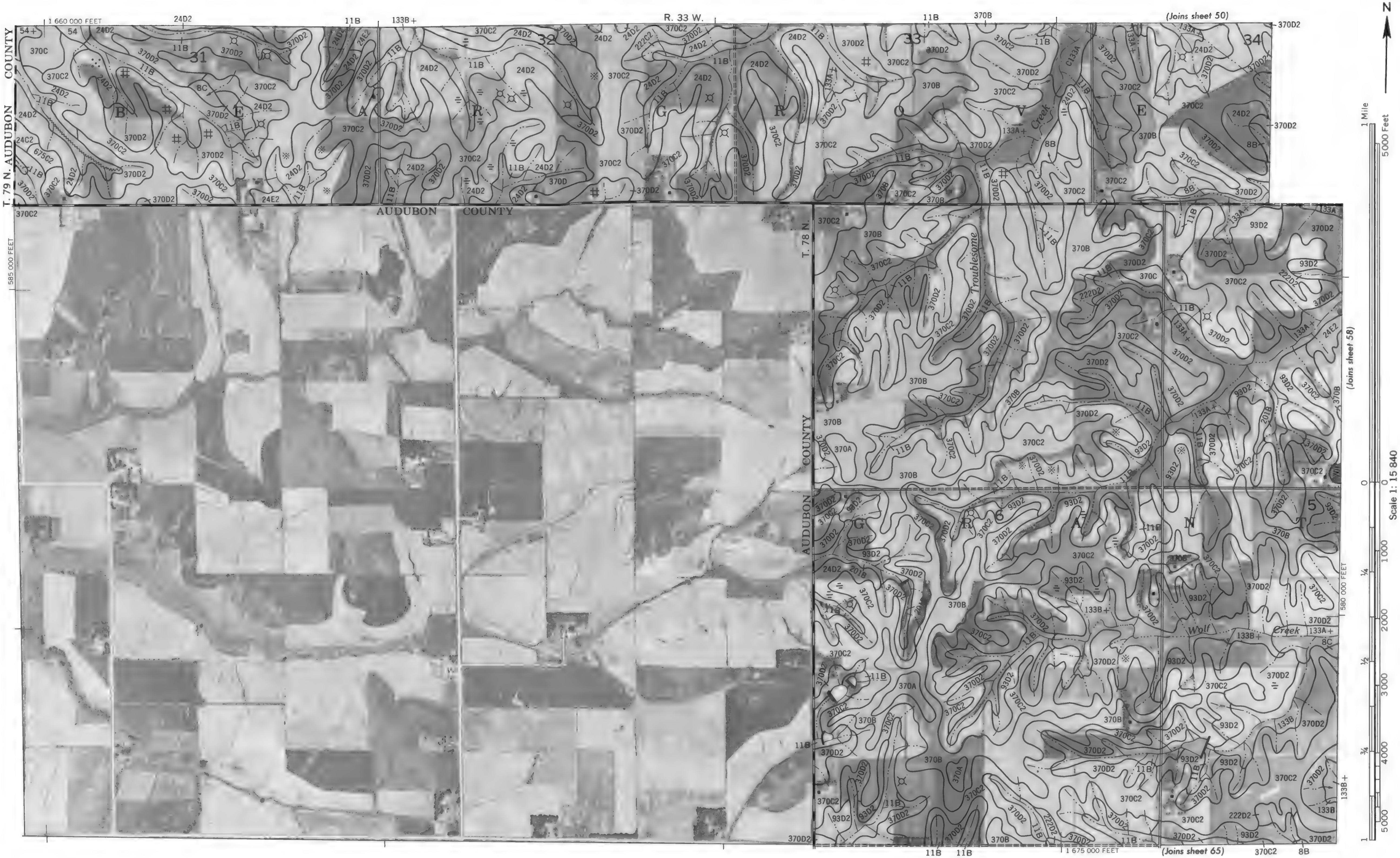
GUTHRIE COUNTY, IOWA — SHEET NUMBER 56

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa

GUTHRIE COUNTY, IOWA NO. 56



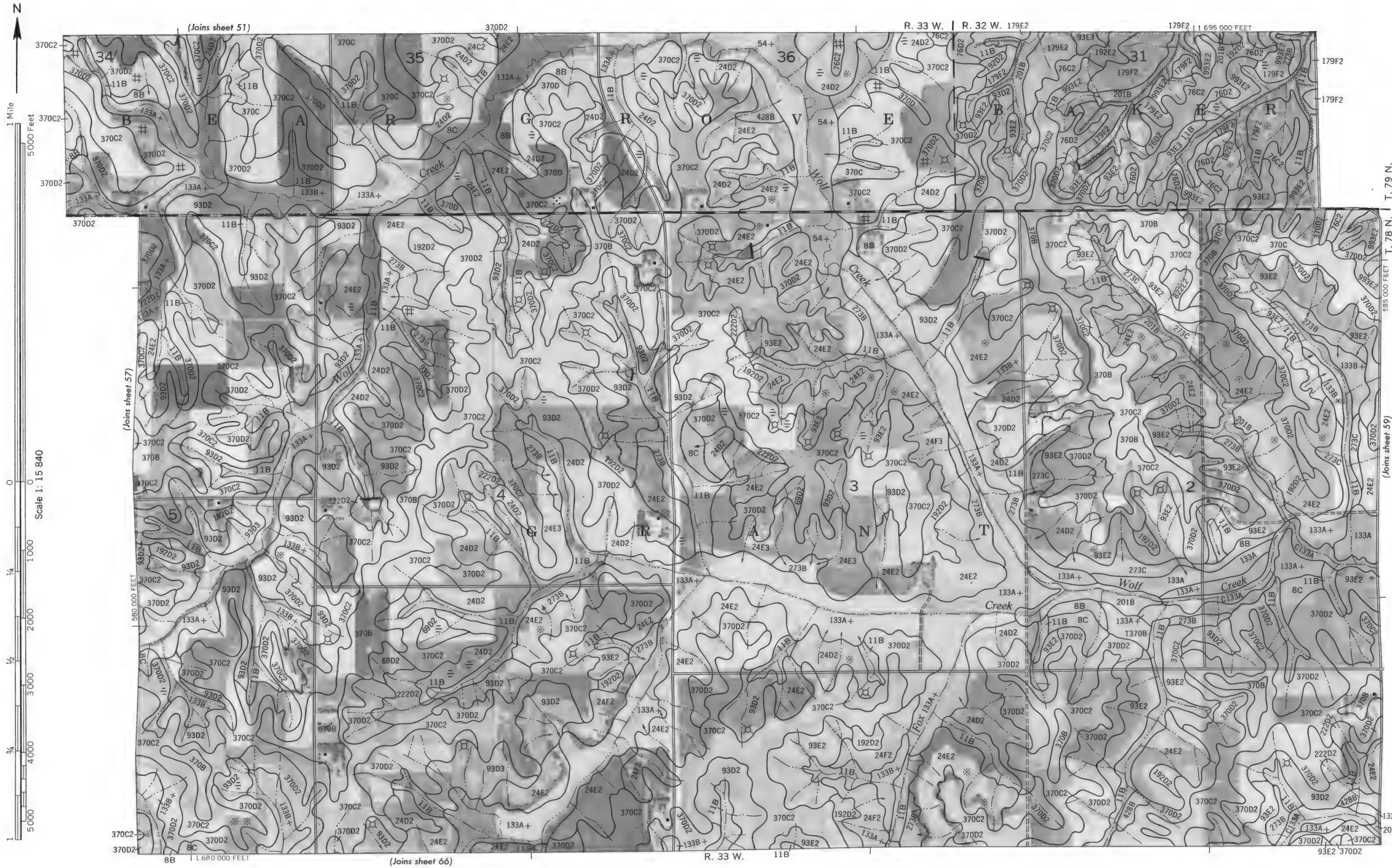
GUTHRIE COUNTY, IOWA NO. 57

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 58

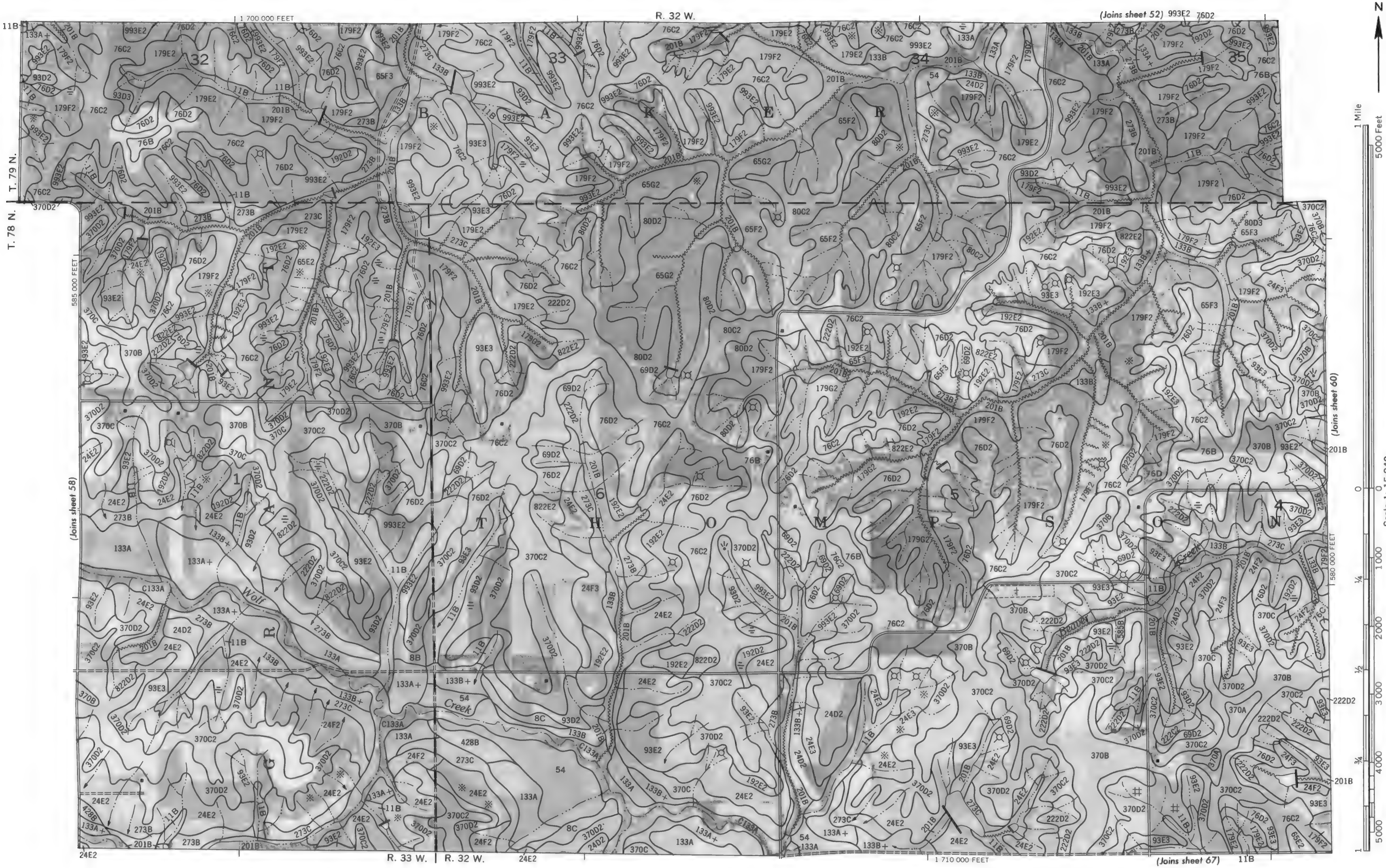


Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

GUTHRIE COUNTY, IOWA NO. 58

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



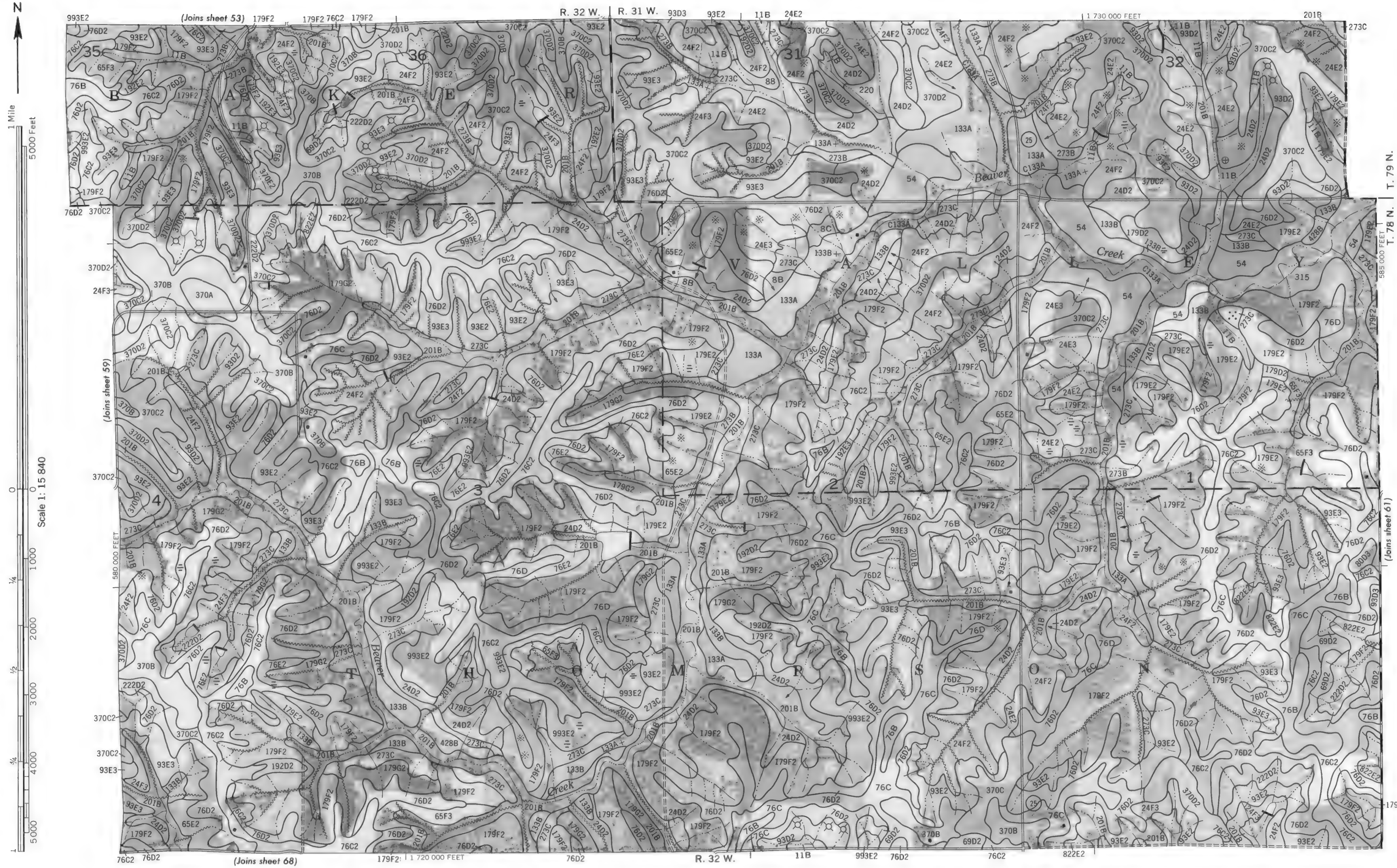
GUTHRIE COUNTY, IOWA NO. 59

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone

GUTHRIE COUNTY, IOWA — SHEET NUMBER 60



Land division corners are approximately positioned on this map

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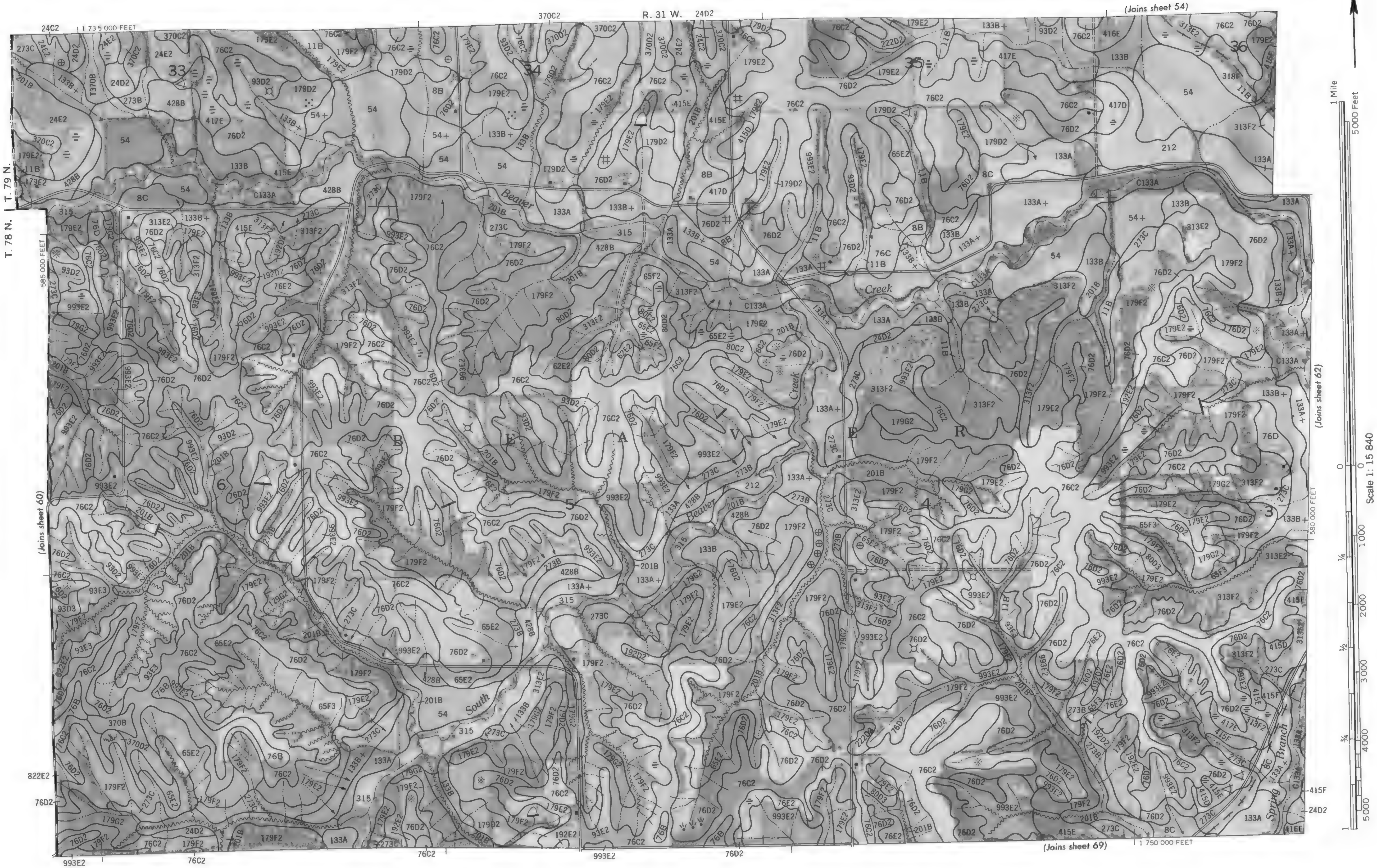
GUTHRIE COUNTY, IOWA NO. 60

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone

GUTHRIE COUNTY, IOWA NO. 61

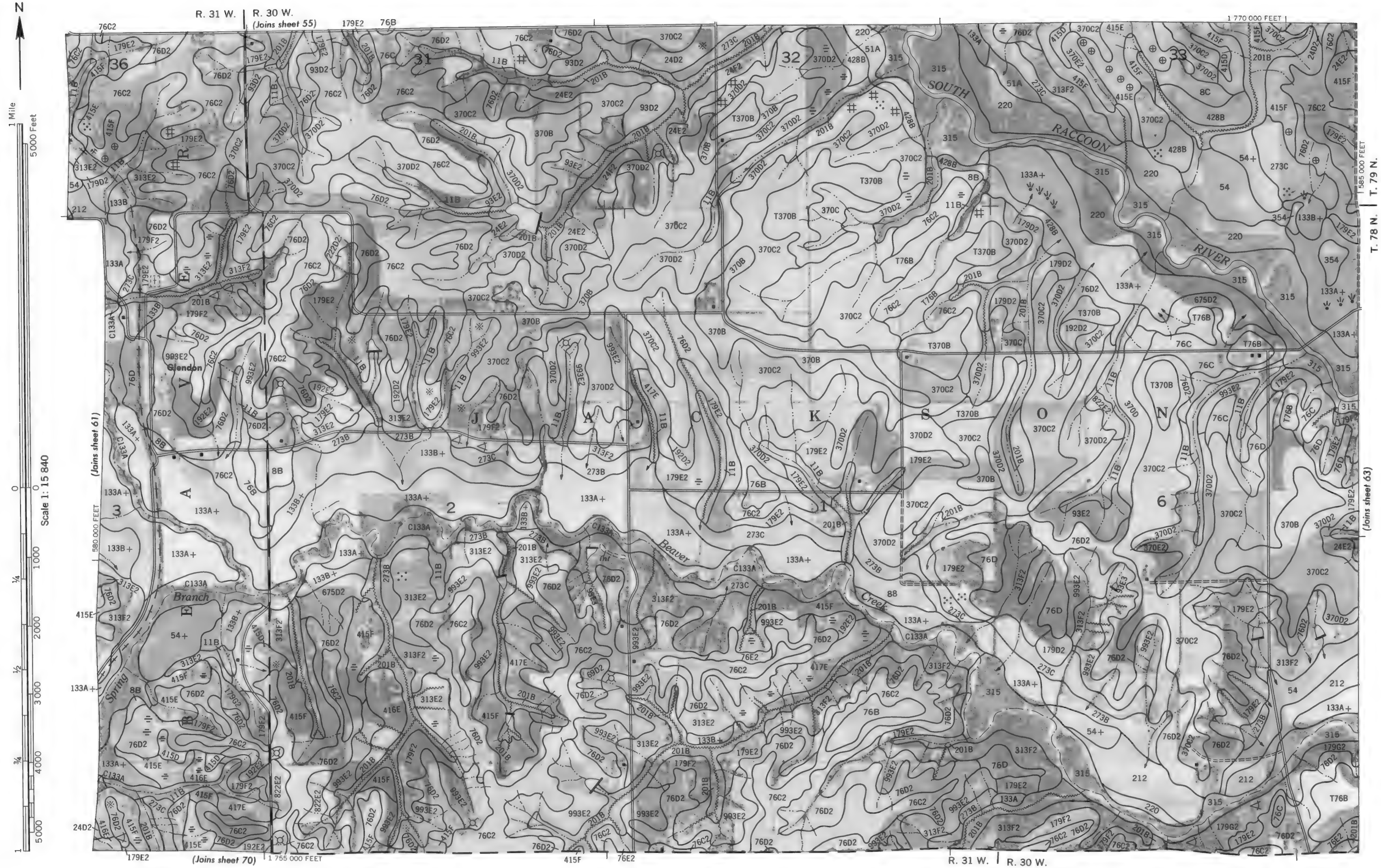
This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 62



Land division corners are approximately positioned on this map.

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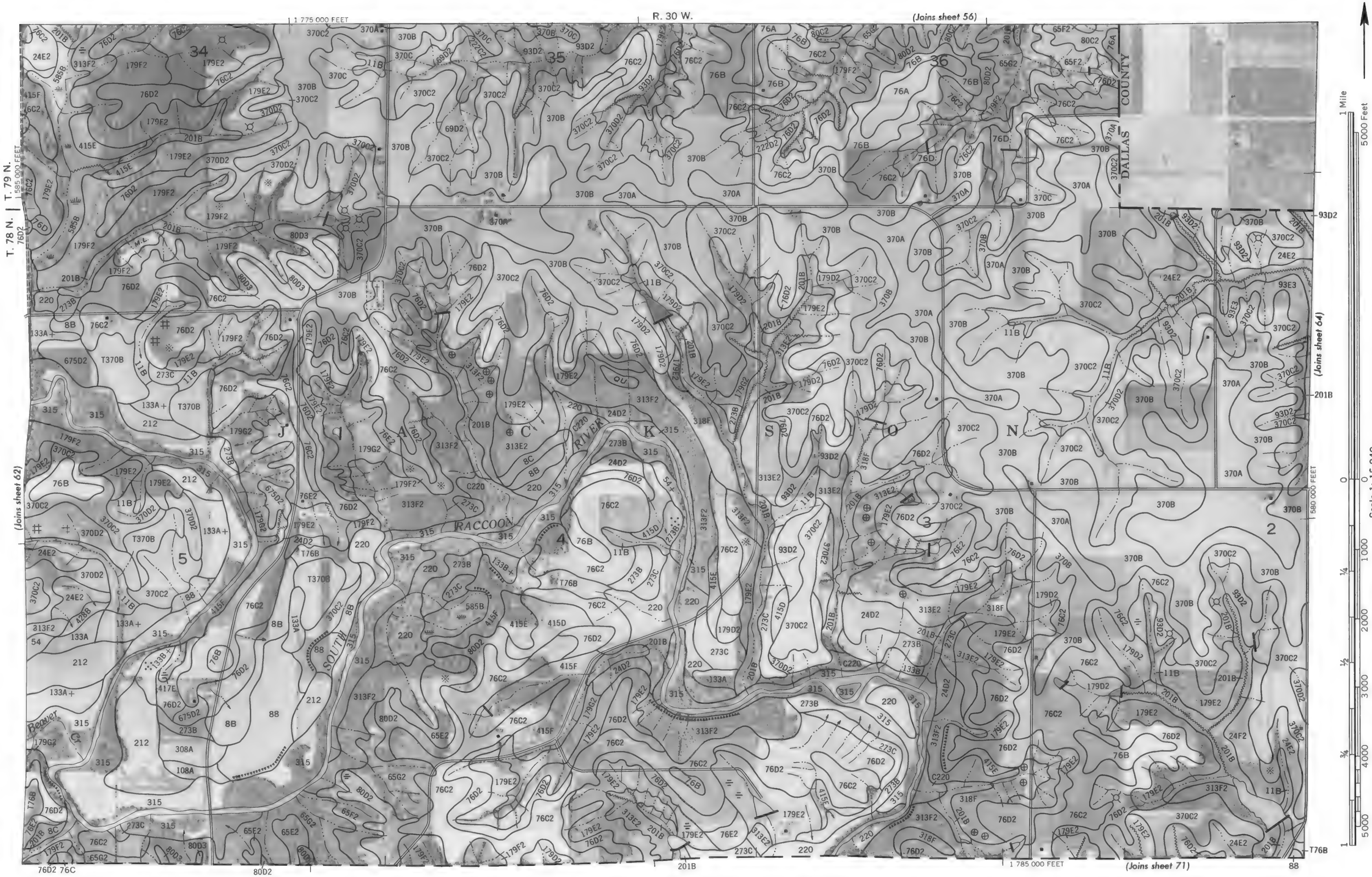
GUTHRIE COUNTY, IOWA NO. 62

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

63



GUTHRIE COUNTY, IOWA NO. 63

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa

Land division corners are approximately positioned on this map.

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GUTHRIE COUNTY, IOWA NO. 64

*Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA NO. 65

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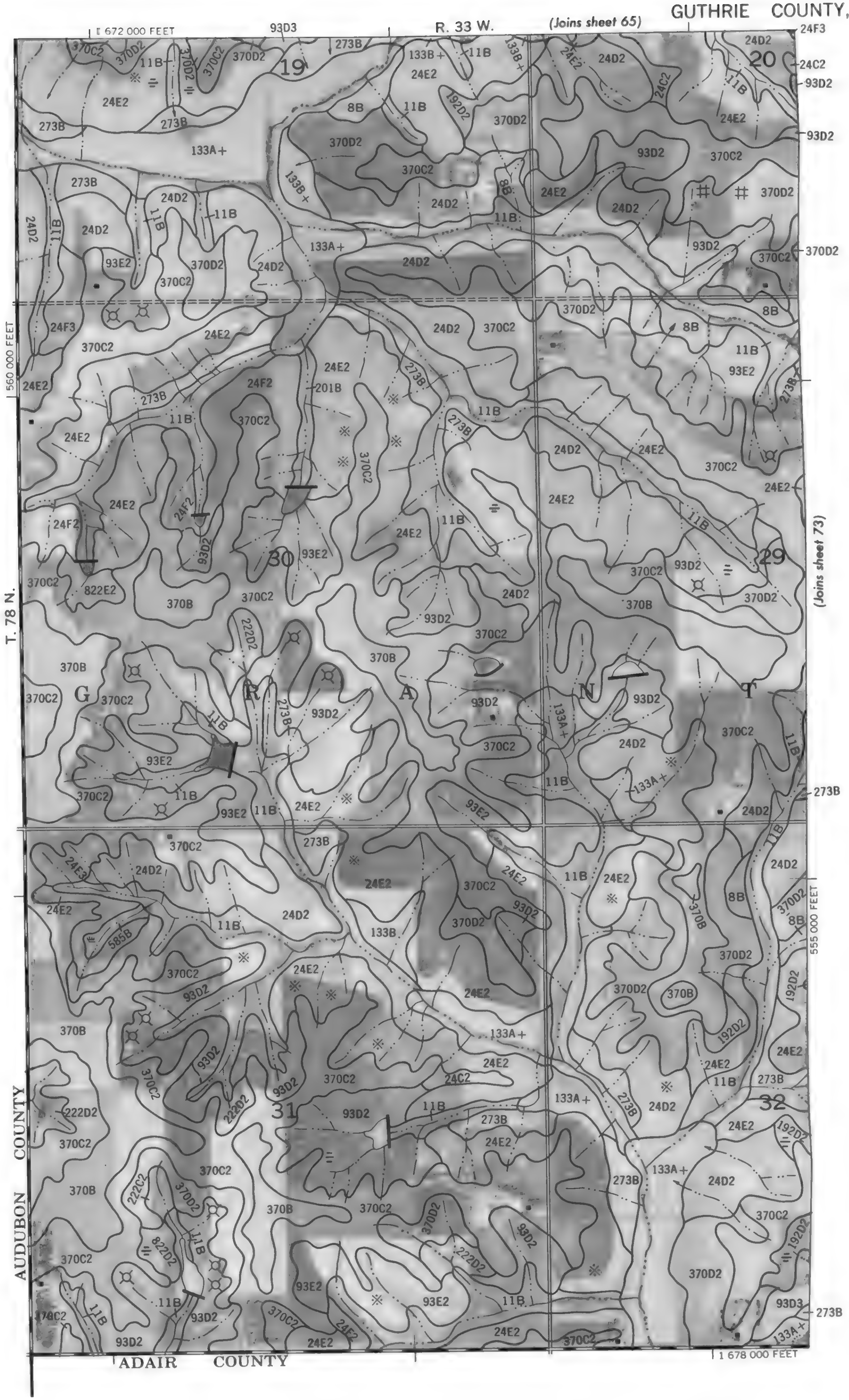
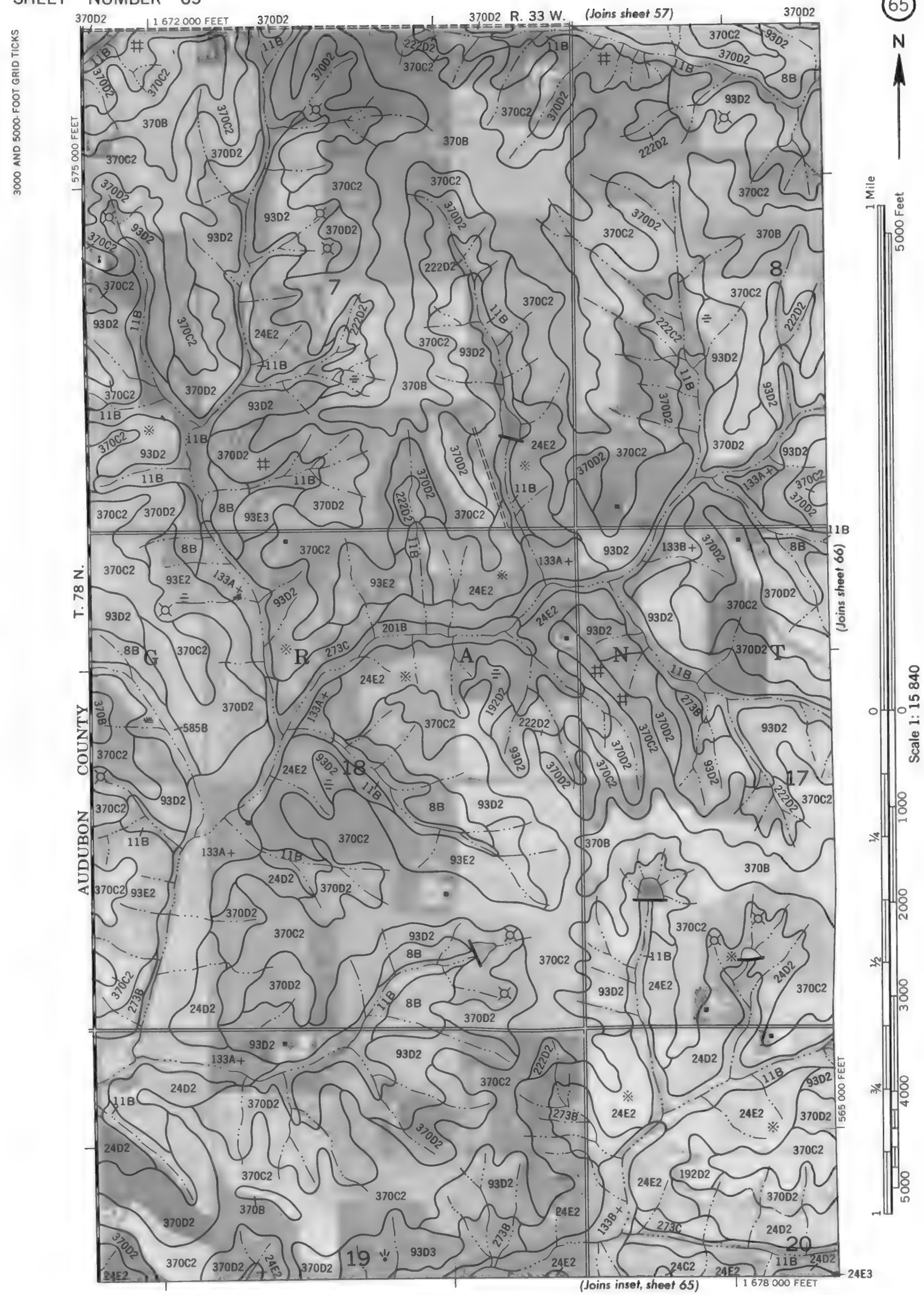
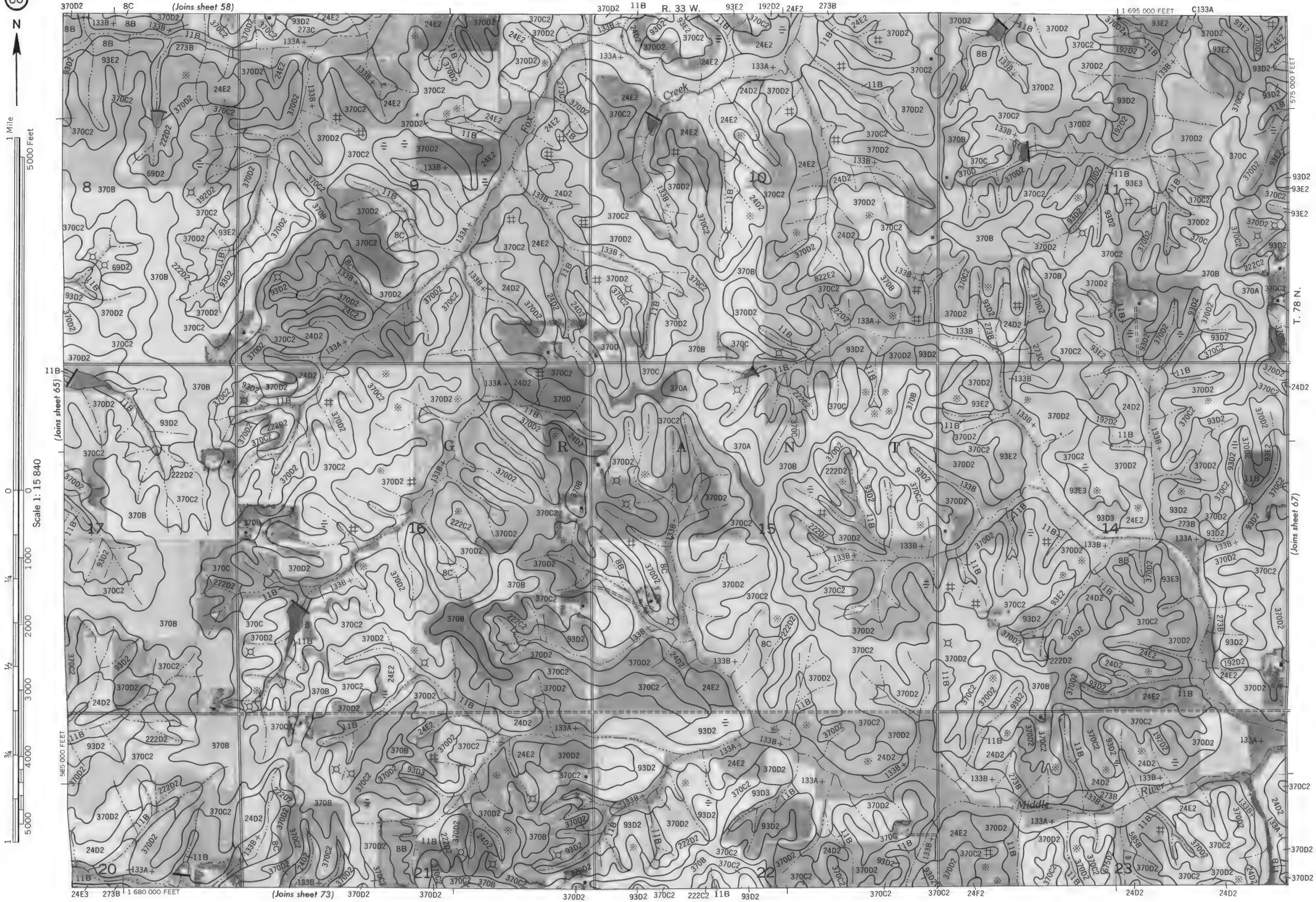
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



3000 AND 5000-FOOT GRID TICKS



GUTHRIE COUNTY, IOWA — SHEET NUMBER 66



Land division corners are approximately positioned on this map.

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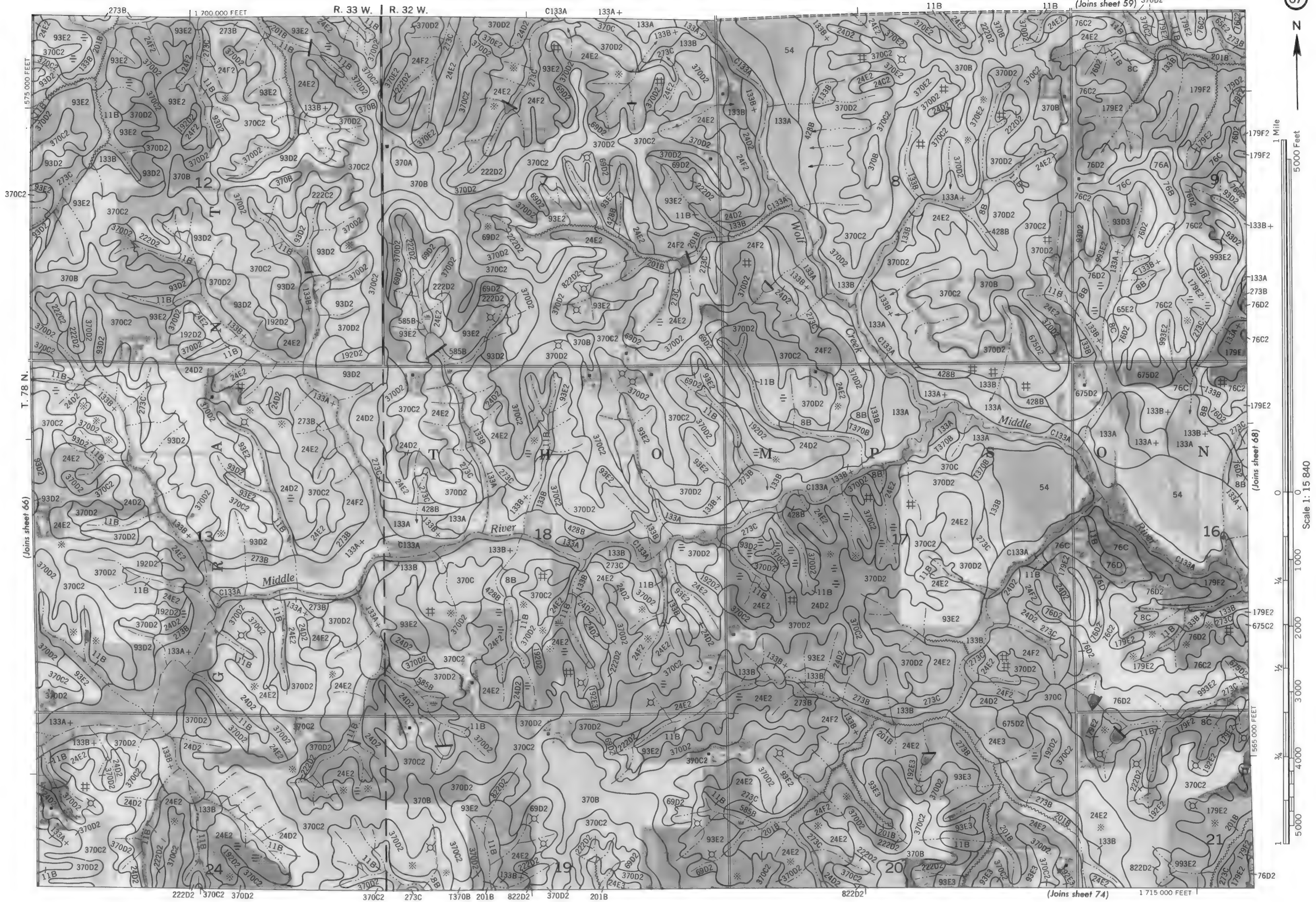
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



GUTHRIE COUNTY, IOWA NO. 67

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

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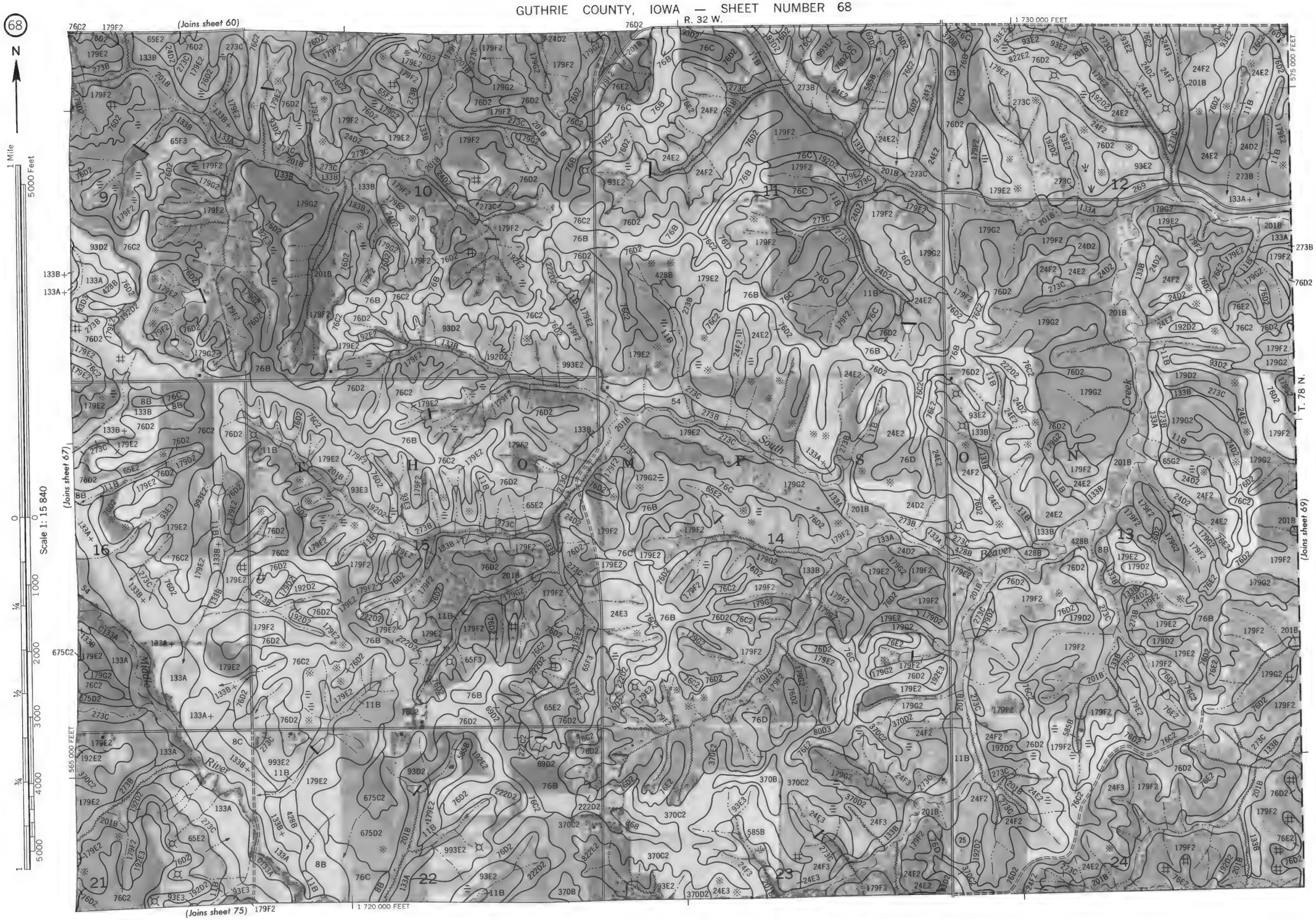
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

Land division corners are approximately positioned on this map.

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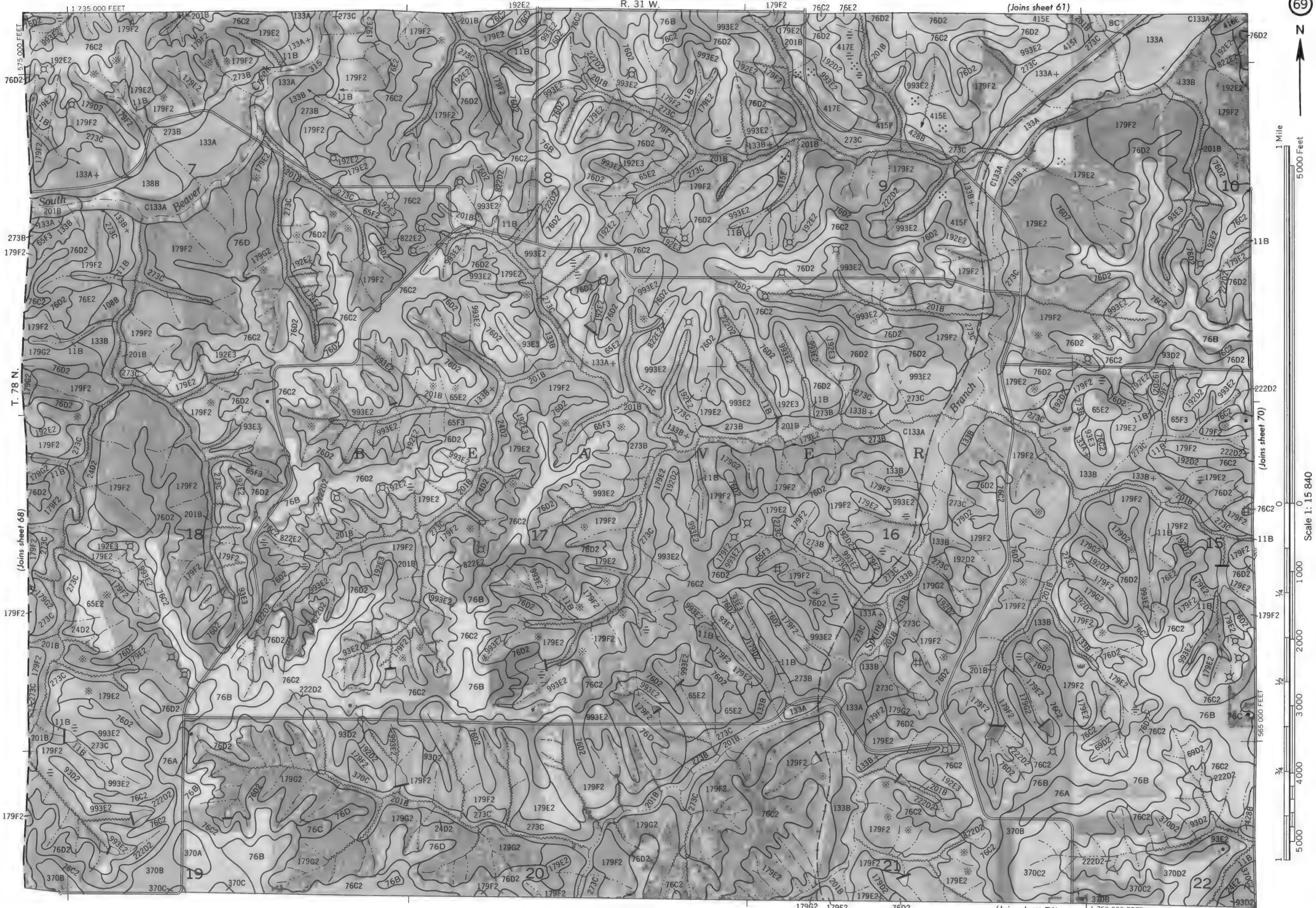

GUTHRIE COUNTY, IOWA NO. 69

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

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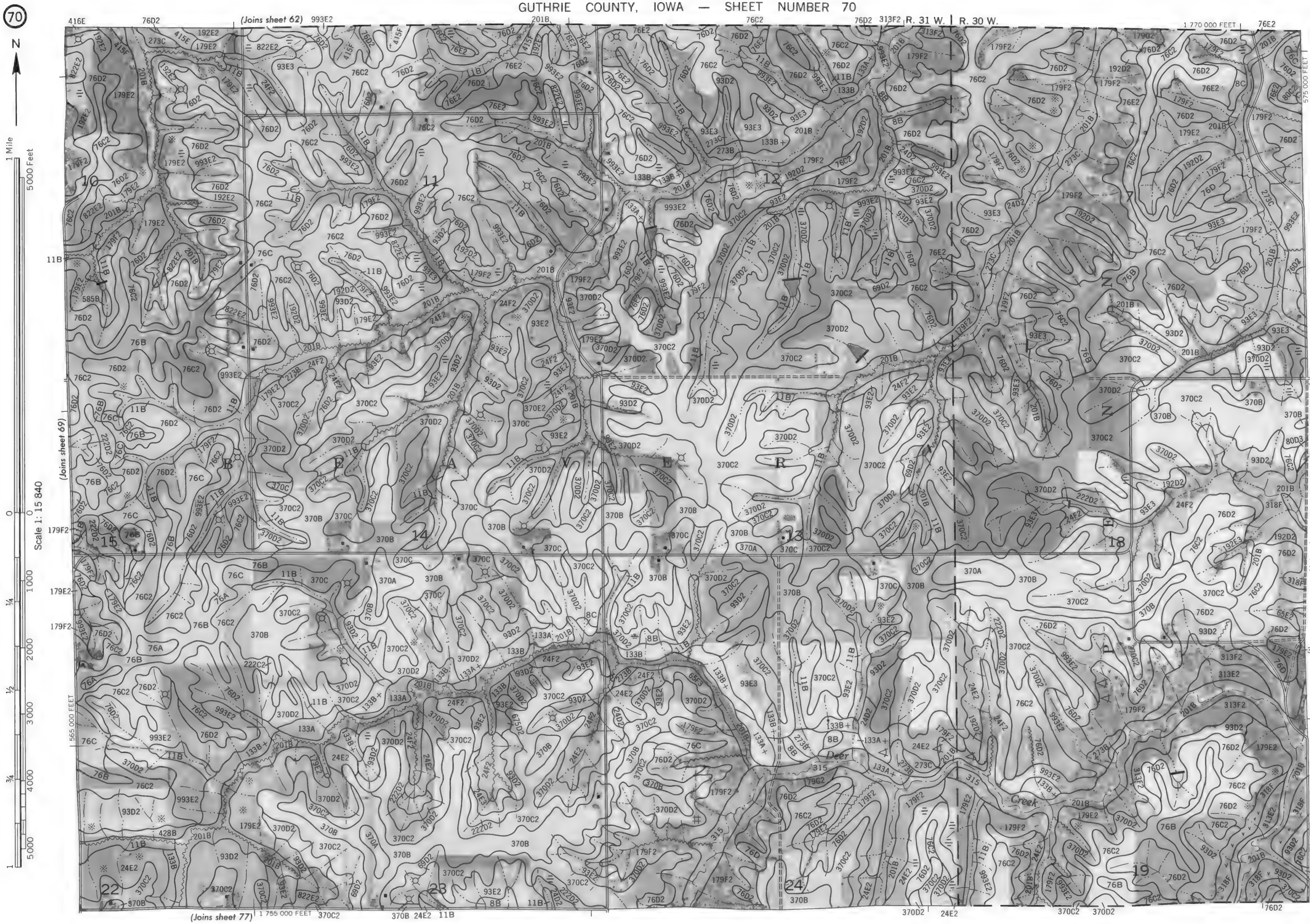
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



Land division corners are approximately positioned on this map.

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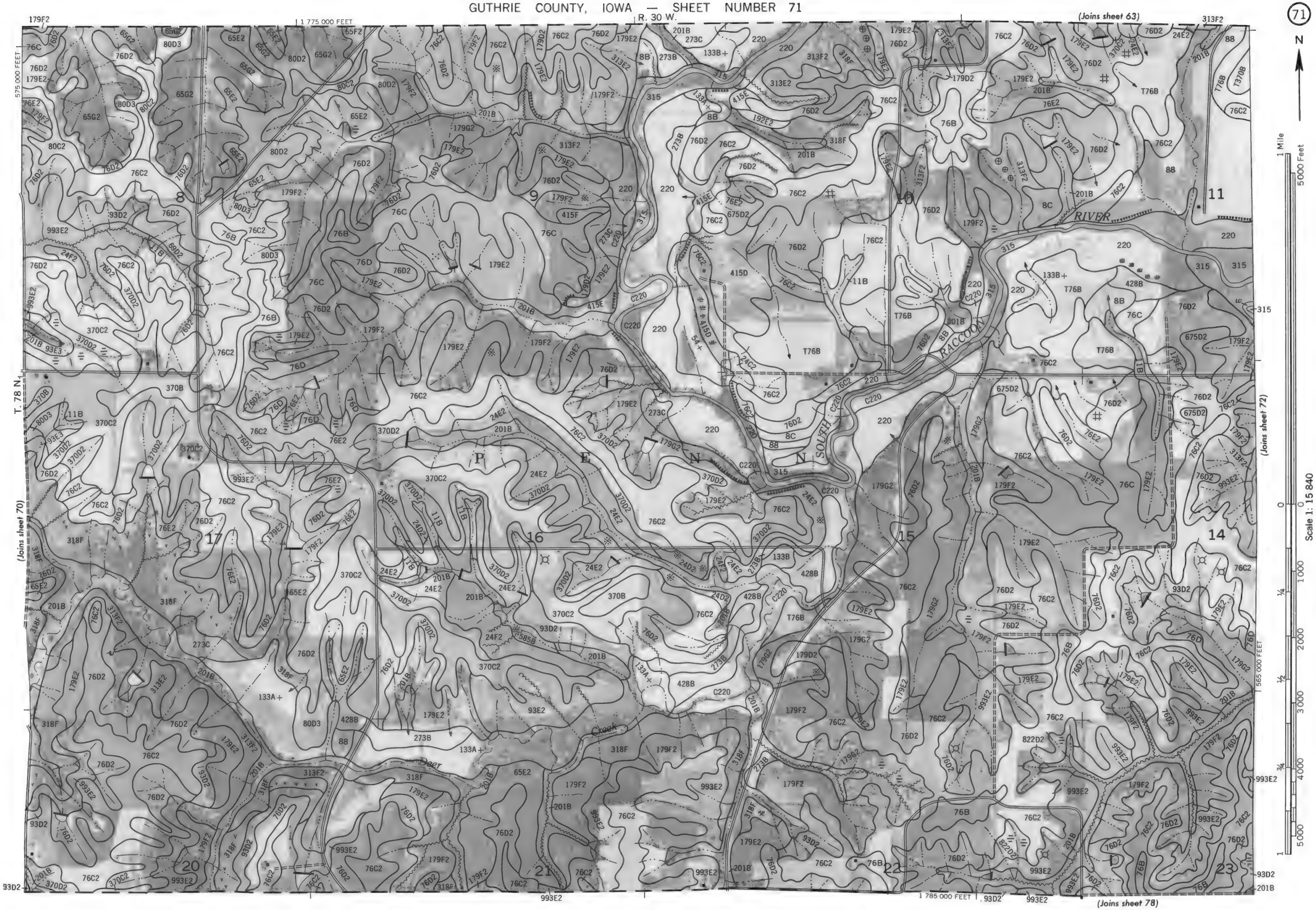
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 71



GUTHRIE COUNTY, IOWA NO. 71

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

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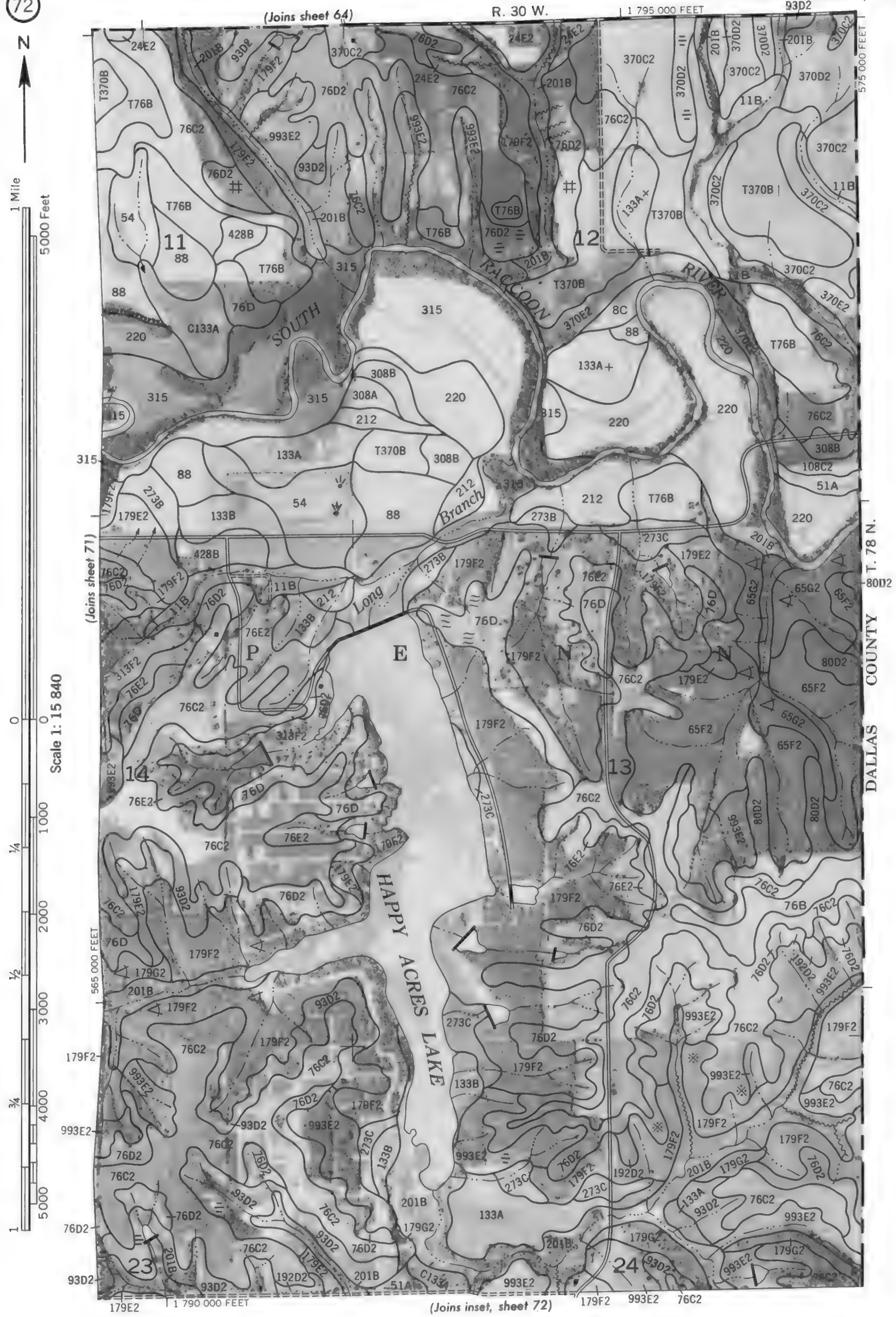
GUTHRIE COUNTY, IOWA — SHEET NUMBER 72



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

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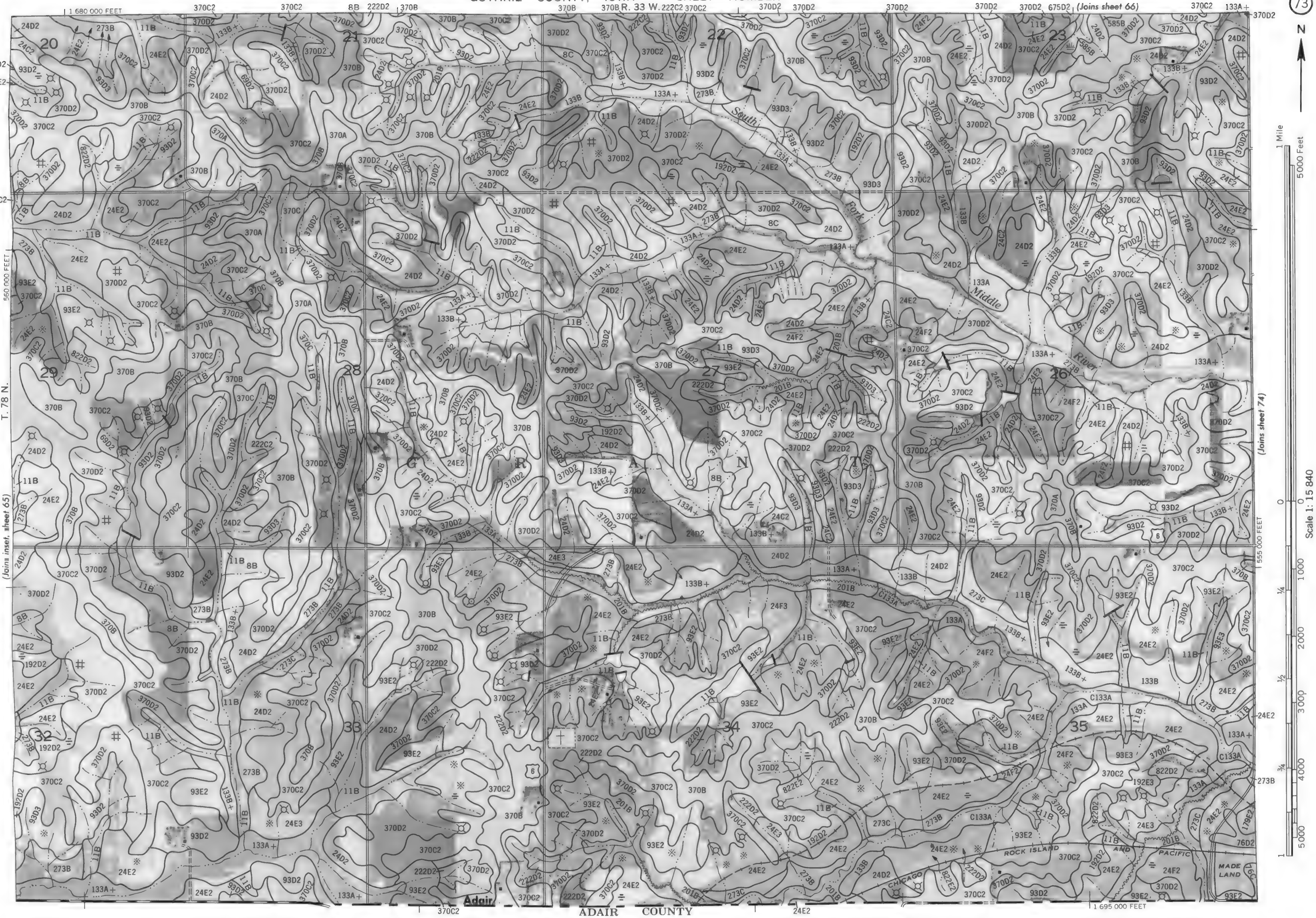
GUTHRIE COUNTY, IOWA NO. 72

GUTHRIE COUNTY, IOWA — SHEET NUMBER 73

73



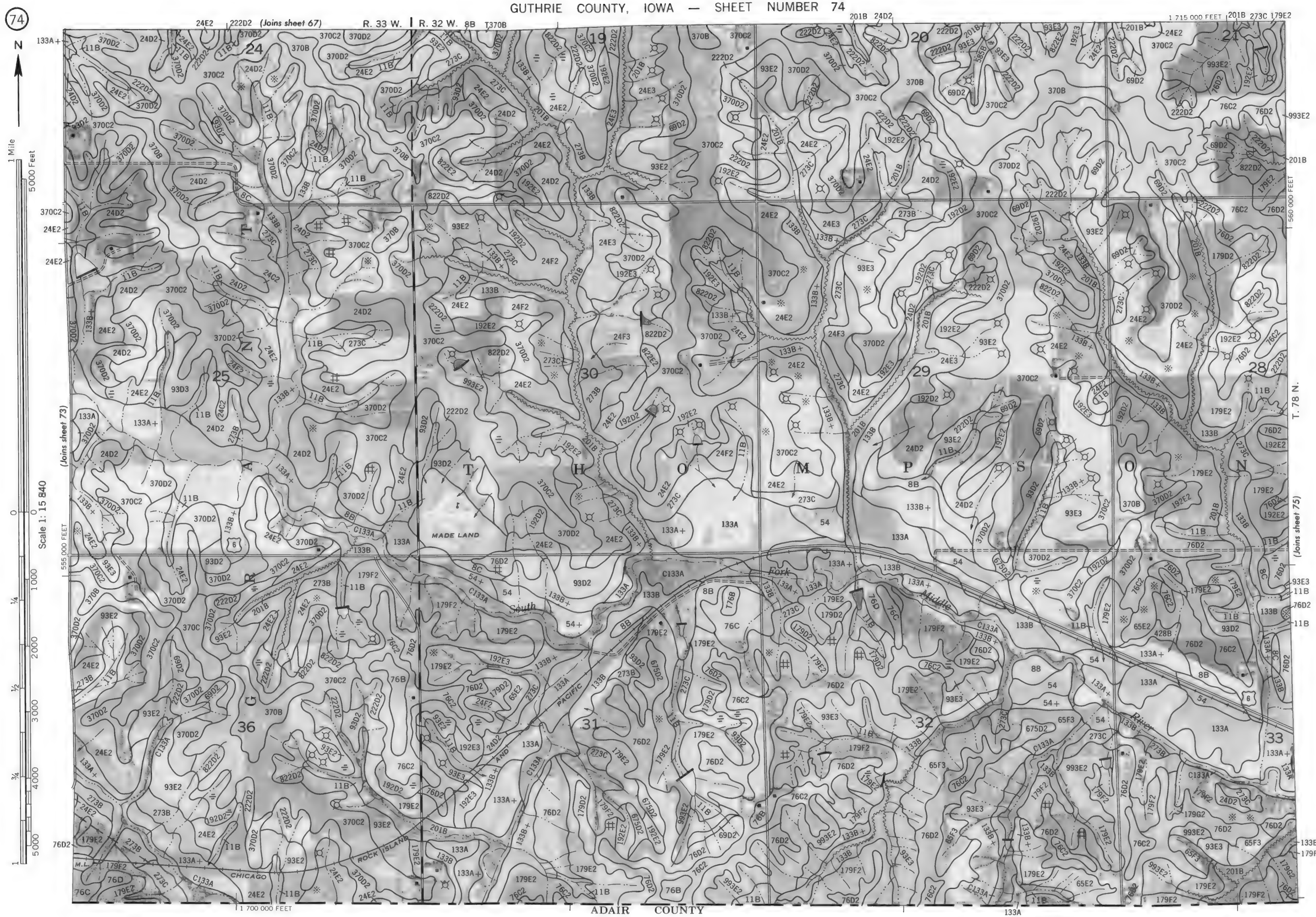
GUTHRIE COUNTY, IOWA NO. 73

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 74



Land division corners are approximately positioned on this map.

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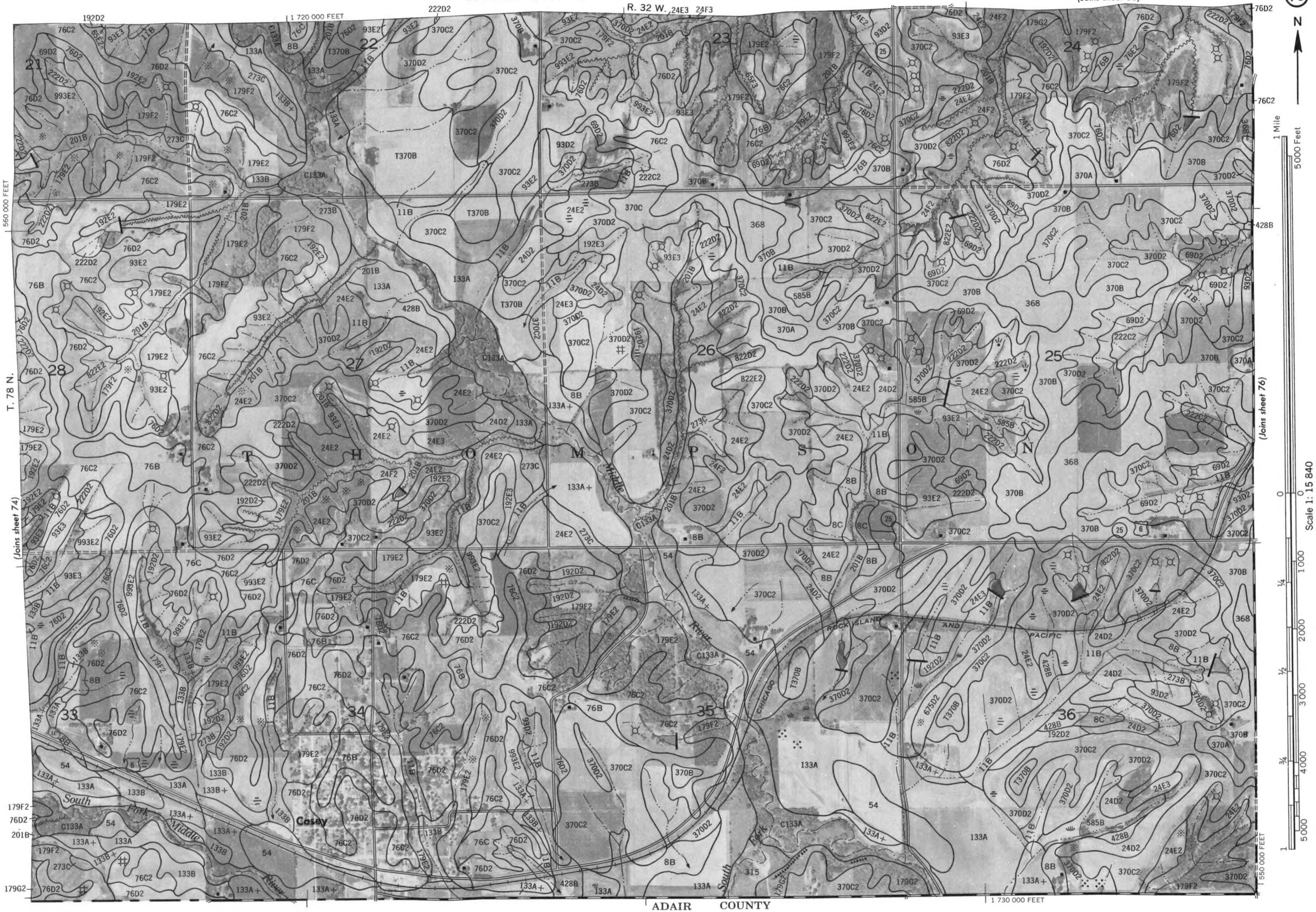
GUTHRIE COUNTY, IOWA NO. 74

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.



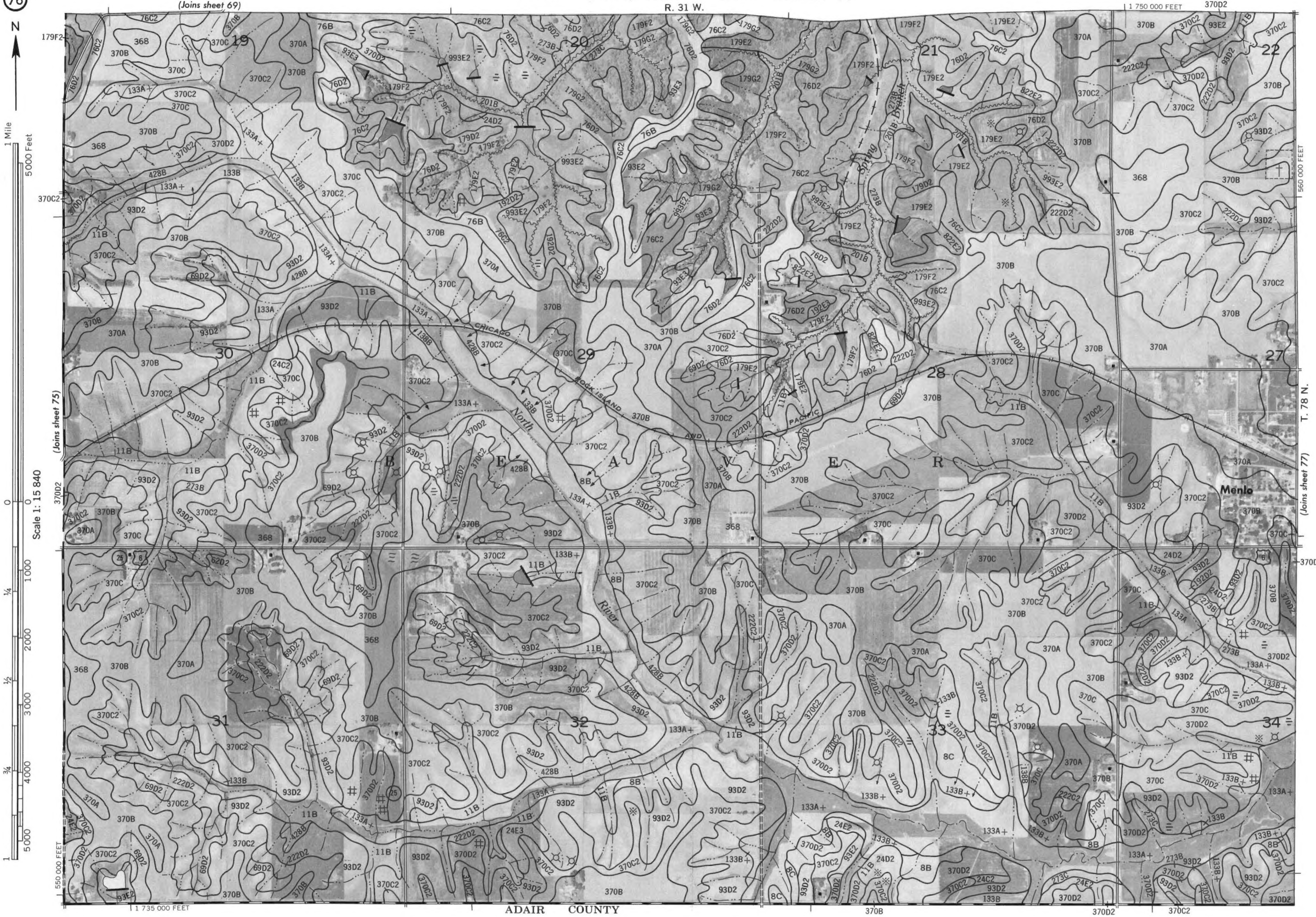
GUTHRIE COUNTY, IOWA NO. 75

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 76



Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

Land division corners are approximately positioned on this map.

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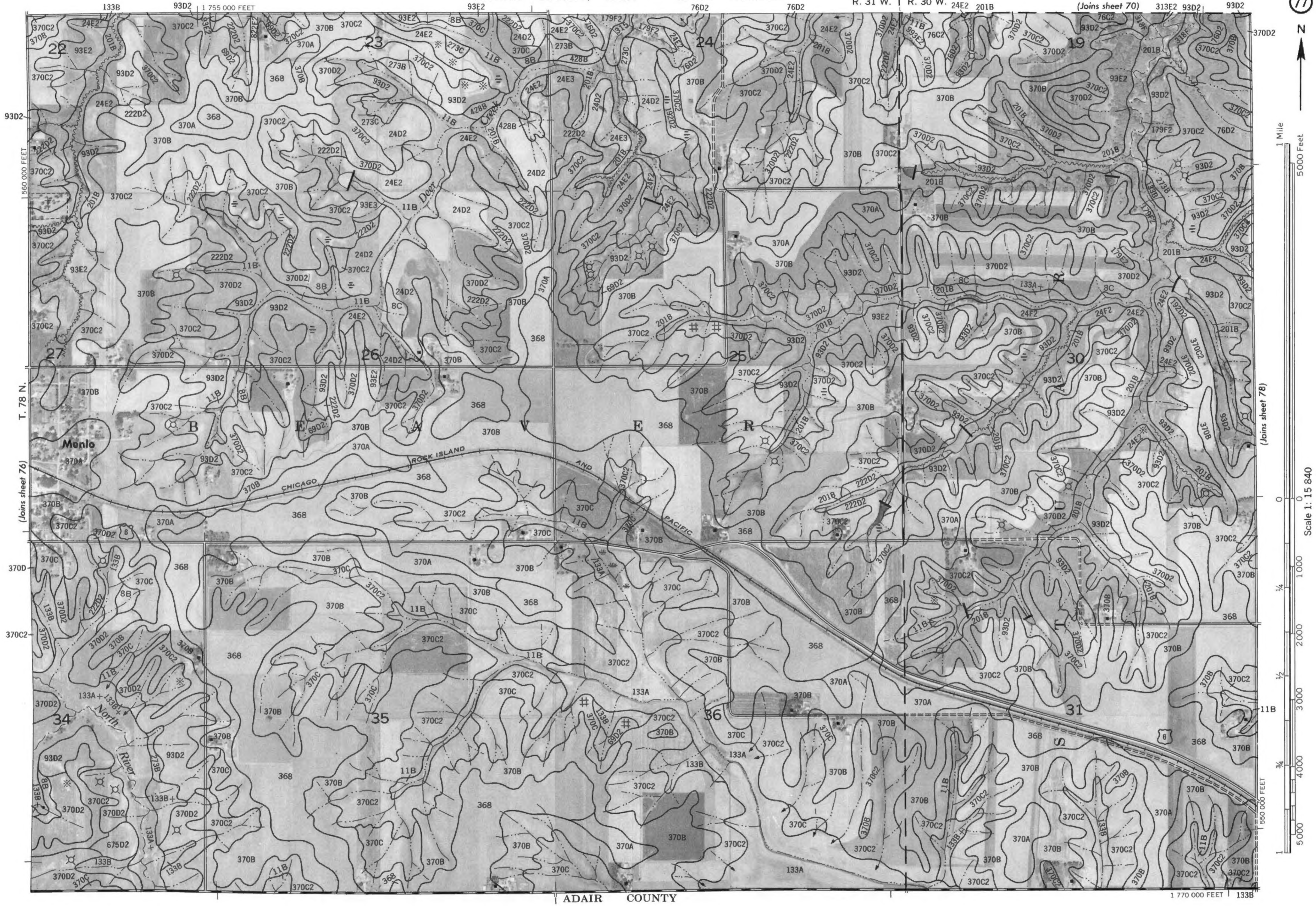
GUTHRIE COUNTY, IOWA NO. 76

GUTHRIE COUNTY, IOWA — SHEET NUMBER 77



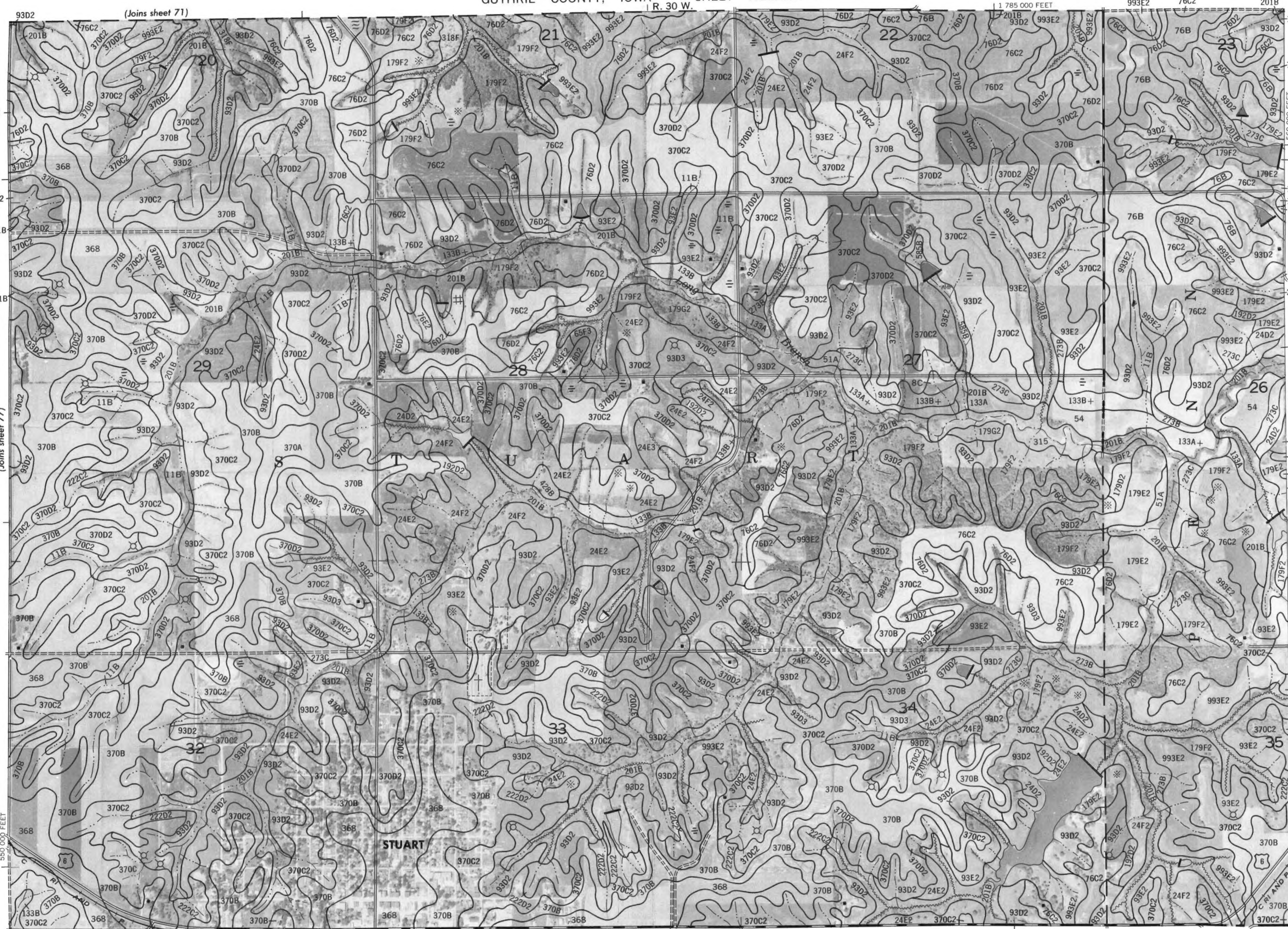
GUTHRIE COUNTY, IOWA NO. 77

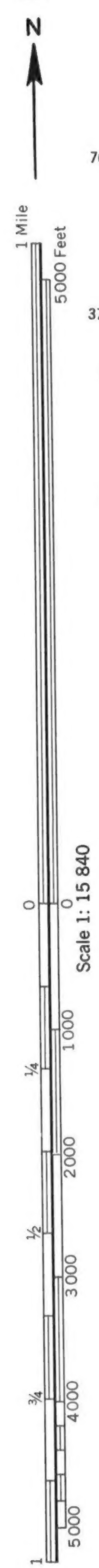
This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University, and the Department of Soil Conservation, State of Iowa.

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

GUTHRIE COUNTY, IOWA — SHEET NUMBER 78





Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Iowa coordinate system, south zone.

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